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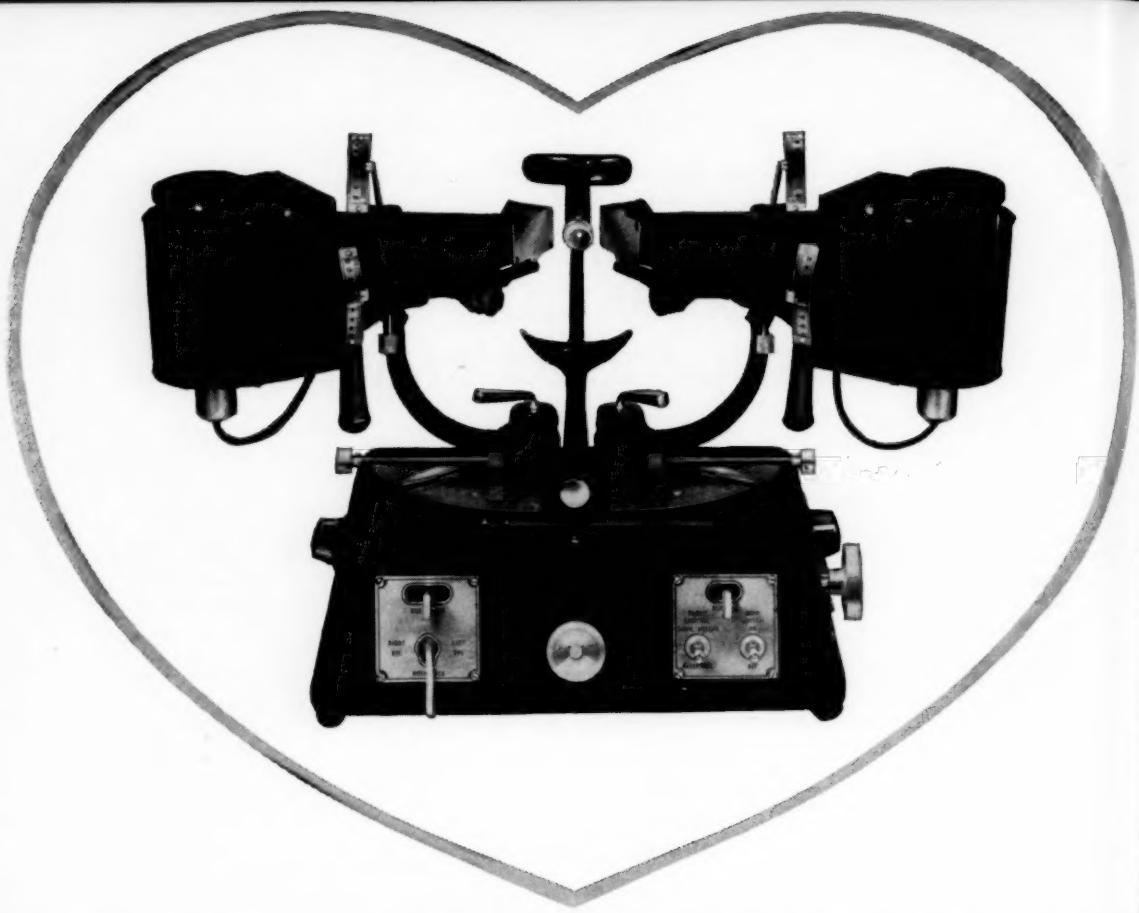

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Symposium: Amblyopia

THOUGHTS ON THE NATURE OF AMBLYOPIA EX ANOPSIA

HERMANN M. BURIAN, M.D.
IOWA CITY, IOWA

ALTHOUGH amblyopia ex anopsia has long been recognized as a clinical entity, there still are many fundamental questions concerning this entity which have not been cleared up and for which there is no unanimous answer.

Certain facts are established, and these must serve as a basis for discussion: (1) by definition, amblyopia ex anopsia is a defect in visual activity; (2) eyes with this type of amblyopia show no detectable pathologic signs which would explain this defect; and (3) in appropriate cases there is the possibility of improving the visual acuity of such eyes by treatment.

A discussion of the nature of amblyopia ex anopsia must also take into account the occurrence of this condition. It is known to occur both in patients with strabismus (strabismic amblyopia) and in patients without strabismus or without a history of strabismus. In either group it may or may not be associated with an anisometropia. When the eyes are isometropic, one is presented with the most clear-cut case of amblyopia ex anopsia. If a significant anisometropia exists, doubts may arise as to whether the amblyopia is purely "functional." While there are, of course, many patients with a high ametropia who have standard visual acuity in either eye, there are also those who have bilaterally reduced visual acuity without visible pathologic changes. Here one may be justified in assuming that the amblyopia is due to more or less subtle anatomic or developmental changes. A similar situation may obtain in patients with unilateral amblyopia of the more ametropic eye.

Considering only amblyopic patients with strabismus, it may be of value to inquire in which forms of strabismus amblyopia is found most frequently. It is general knowledge that amblyopia occurs far more often in patients with unilateral strabismus than in patients who tend to alternate fixation. This clinical impression was confirmed by Costenbader and his coworkers,[8] who reported that only 5 of their 62 patients with alternating esotropia had any amblyopia, whereas an amblyopia was present in 120 out of 239 patients with uniocular esotropia. These authors have also shown that amblyopia occurs three times more frequently in patients with constant strabismus than in patients with intermittent strabismus, and that a similar ratio prevails between convergent and divergent strabismus. All this would lead one to think that the use to which an eye is put during the years of growth and development is in some way linked to its visual acuity. This thought will be discussed presently in more detail.

The evidence from the result of therapy also deserves attention in connection with the question of the nature of amblyopia ex anopsia. It has been established beyond

From the Department of Ophthalmology, College of Medicine, State University of Iowa.

Read at the Annual Joint Meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians, Oct. 9, 1955, Chicago.

doubt that occlusion of the fixating eye, especially together with planned exercises for the amblyopic eye, is helpful in restoring visual acuity to the amblyopic eye. However, opinions differ as to the degree of helpfulness of these measures and as to the permanence of the results.

Occlusion is unquestionably most effective in the preschool age, and its effectiveness rapidly decreases with the passing of the years. It is the experience of some excellent clinicians that the acuity of amblyopic eyes can be improved even if treatment is begun after the age of 8 or 9 years, but that the acuity in such cases tends to diminish unless binocular vision is achieved. To this must be added the observation that the visual acuity of the occluded eye is sometimes remarkably reduced in young children, whereas in adults the eyes may be occluded for years from the act of fixation (for example, by a cataract) without loss of visual acuity after successful removal of the obstacle. Occasionally, one sees an adult, even an elderly patient, who regains a considerable degree of vision in an amblyopic eye upon loss of the fixating eye.

It stands to reason that it is easier to improve the vision of an amblyopic eye in a small child during the "plastic" stage. But it would not seem that this, alone, could account for the decreasing success of occlusion with succeeding years. As children grow older, it becomes increasingly difficult to carry out the therapy successfully. In the small child, the will of the parents acts as the motivating factor; older children are more independent, more engaged in school and social life, and successful therapy becomes more and more difficult. The importance of motivation was very clearly seen in the remarkable success achieved with therapy of amblyopia in teen-agers during the last war when young men were eager to improve their vision in order to qualify for service in certain branches of the Armed Forces.

The greater permanence of the result of occlusion if binocular vision is achieved, the occasional decrease in acuity of the occluded fixating eye, the occasional recovery of vision in the amblyopic eye after the loss of the fixating eye in adults—all these observations point toward the role of usage or the lack of usage in the cure as well as in the establishment of an amblyopia ex anopsia. Therefore, one of the early concepts (and indeed, still a current one) was that amblyopia ex anopsia is in fact an *amblyopia of disuse.*

Pondering this very reasonable interpretation of amblyopia, one encounters some difficulties. What, actually, do we mean by "use" and "disuse" of the eye? I believe that the concept of "amblyopia of disuse" has arisen from an analogy to the well-known atrophy which muscles undergo when they are not used for a prolonged time. But surely nothing atrophies in an amblyopic eye. A patient with such an eye "uses" this eye a good deal. Light enters into it, images are formed on the retina, and if it is occluded the patient will notice a loss in his field of vision. The only thing for which such an eye is not used habitually is central fixation. Accordingly, one should designate an amblyopic eye as an eye which has not been used for central fixation for a long period of time during the years of development and has consequently lost the ability to discriminate form to some extent.

This presupposes, of course, that fixation is necessary for the development of central visual acuity. This is possible and some may even say likely, especially in view of the highly interesting new evidence presented by Riesen [20, 21] regarding the effect of early deprivation of light and pattern vision on the visual performance of chimpanzees and cats. However, this whole problem is as yet by no means resolved. It must be taken into account, as will be shown later, that the macular function of the amblyopic eye is essentially normal except for form vision. Consider also the

transient, though very marked, reduction of visual acuity in the deviating eye of patients with alternating strabismus, but with normal vision when either eye fixates. The active suppression in these patients, which is one of the adaptive mechanisms with which the patient with strabismus avoids diplopia and confusion, occurs not only in the macular area, but also in the peripheral retinal area on which the object fixated by the other eye is imaged. These several observations have led to the view that amblyopia ex anopsia does not result from disuse but rather from an active inhibition of the macular function of form vision. Those who hold this view speak accordingly of an *amblyopia of inhibition* or of *suppression amblyopia*. The thought is that suppression has become obligatory through prolonged reinforcement and is carried over from binocular vision into monocular vision.

Some writers combine the concepts of amblyopia of disuse and suppression amblyopia and believe that the latter may be superimposed on the former. Thus Chavasse[7] spoke of an *amblyopia of arrest*, meaning thereby that the turning, and consequent "disuse," of an eye results in an arrest of the development of visual acuity.* If this arrest were allowed to persist for some time, therapeutic measures could remove only that portion of the amblyopia which was added by suppression onto the amblyopia of arrest. Visual acuity could then be restored only to the level which had been reached at the time when the child stopped using the eye for fixation.

This theory encounters similar difficulties, as does the "usage" theory of which it is a variant. In addition, there is good clinical evidence to show that visual acuity can actually be restored to a much higher level than the one indicated by the age of the patient at the onset of the constant deviation. This has been emphasized by this writer as well as by Keiner.[11] It is also evident from the data of Costenbader and co-workers[8] that the duration of the squint is more closely correlated to the appearance of an amblyopia than is the age of the patient at onset of squint.

The theory of an amblyopia of arrest points to the practical significance of the inquiry into the nature of amblyopia ex anopsia. The attitude assumed by the physician toward the treatment of this condition will depend in large measure on the concept which he has formed about its nature. For example, it would surely make a difference in his approach to the therapy of amblyopia if he believed that it is a congenital condition, based on an organic (anatomic) defect.

In this presentation it has been tacitly assumed that amblyopia ex anopsia is the *consequence* rather than the *cause* of strabismus, a view which is now generally accepted, at least for the type of amblyopia commonly met with in cross-eyed children. This has not always been so. Not many decades ago there were ardent advocates of the opinion that even this type of amblyopia was congenital in origin, due to some organic defect, and productive of a misalignment of the eyes in a manner analogous to the acquired strabismus of an adult who has lost vision in one eye owing to disease or injury. The thought that amblyopia ex anopsia may be due to some organic abnormality is not entirely lost even today. As late as 1950, Strazzi[22] expressed the belief that amblyopia was congenital and the most important factor in the etiology of strabismus, that it could be transmitted by heredity, and therefore, that it also had a predominant influence on hereditary strabismus.

In 1934 Teräskeli[23] studied the critical flicker fusion frequency of 50 patients with amblyopia and found that the behavior of the amblyopic eye differed from that of the normal eye. In all normal eyes the

*Linkszl (12)" states that an eye does not "develop" amblyopia but stays amblyopic. This certainly does not hold true for children who lose visual acuity in the occluded fixating eye.

critical flicker fusion frequency was, on an average, 11 per cent higher in the periphery than in the center. In 30 of the amblyopic eyes the values for the periphery were also higher but, on the average, only by 5.8 per cent; in 17 amblyopic eyes the peripheral and central values were the same; and in 3 amblyopic eyes the central value was lower. On the whole, then, the normal differentiation into a "central" and "peripheral" retina seemed to be missing in amblyopic eyes. Since the critical flicker fusion frequency is thought to be dependent upon retinal events, Teräskeli concluded that the cause of amblyopia was likely to be a congenital anomaly of the retina, consisting either of an abnormal relative distribution of the rods and cones or of an abnormal arrangement of the synaptic pathways in the retina.

It is of interest to contrast the findings of Teräskeli with those of Weekers,[25] who stated that he found the critical fusion frequency to be normal or even better than normal in eyes with amblyopia ex anopsia. This strongly suggested to him that the underlying mechanism in amblyopia was not ocular but cerebral.

Quite recently, Miller[16, 17] has come to the conclusion that the reduced visual acuity in amblyopia is not related to the active type of suppression which makes it possible for the patient with alternating strabismus to block out the vision of either eye. On the basis of his findings, he believes that the reduction in vision of the amblyopic eye is a manisfestation of impaired brightness discrimination. He assumes that the cause of this impairment is an undue irradiation of excitations in the fovea of the amblyopic eye, owing to an absence of inhibition present in the normal fovea. Miller also assumes an anatomic structural abnormality and deplores the lack of information regarding the histology of the retina of the amblyopic eyes.

Brightness discrimination had been previously studied by Ludvigh,[13,14] who found, using high levels of illumination, that in some instances the brightness discrimination of the amblyopic eye was essentially the same as in the sound eye, whereas in other instances the sensitivity of the amblyopic eye was from 5 to 20 times lower than that of the sound eye. He felt that this test might be used as a prognostic device, since patients in the first group would respond better to occlusion than those in the second group. Irvine,[10] using a similar method, did not encounter the extreme differences between normal and amblyopic eyes reported by Ludvigh.

In a later presentation, briefly quoted in the Proceedings of the New England Ophthalmological Society, Ludvigh[15] stated that light difference sensitivity is as good in the amblyopic eye as in the sound eye when the object is a disc subtending 25 degrees. With decreasing disc size the sensitivity of the amblyopic eye becomes poorer than that of the fellow eye. On that occasion Ludvigh advanced the hypothesis that "on-off elements, assumed to exist in the human eye, mediate binocular fixation, contour perception and visual acuity, and that these elements, or the neural output thereof, are 'suppressed' in the initial stages of amblyopia ex anopsia."

Recently Pugh[19] published an interesting study on foveal vision in amblyopia. In this study, the visual acuity of the amblyopic eye, as measured on a major amblyoscope, was determined while the sound eye was occluded and while it was not occluded. In a large number of cases it was found that the acuity of the amblyopic eye was higher when the sound eye was patched. The strength of the inhibiting effect of the activity of the good eye on the bad eye was determined by reducing the light transmitted to the good eye by means of neutral filters. In many cases, reduction of the light to 1/100, or even to as little as 1/10,000, would restore the resolving power of the amblyopic eye to its monocular standard. Pugh concluded that in the cases in which such an influence of

the sound eye on the acuity of the amblyopic eye could be demonstrated, the probable main site of inhibition lies in the cortex.

The fact that the seat of the disturbance in amblyopia may be in the retina rather than in the central nervous system does not necessarily imply that there are actual congenital anatomic differences between the retina of the normal and of the amblyopic eye. It has been postulated that processes of inhibition, though possibly originating in the central nervous system, extend all the way down into the retina.

This view was expressed by Harms,[9] who found an inversion of the pupillomotor sensitivity of the amblyopic eyes. In the normal eye the pupillomotor sensitivity is greater (that is, the threshold of the light reflex is lower) if the central area of the retina is stimulated by light than if the periphery is stimulated. In the amblyopic eyes the pupillomotor sensitivity of the retinal center is depressed. Since the pupillomotor pathways separate from the visual pathway prior to reaching the lateral geniculate body, the seat of the inhibition, according to Harms, must be in the synapses of the retina itself.

Bárány and Halldén[2] indirectly confirmed Harms' findings on normal eyes in that they observed a phasic inhibition of the pupillary light reflex during retinal rivalry when the suppressed fovea was stimulated. These authors have, however, also observed that central nervous depressant drugs may weaken and even completely abolish retinal rivalry.[1] Since they conceive of amblyopia as a phenomenon of suppression, closely related to retinal rivalry, and believe that the fixing eye inhibits the affected eye, they have tried alcohol as a therapeutic agent in amblyopia and have apparently obtained encouraging results in one case.[3]

Bietti[4,5] has associated himself with those who think that suppression in squint is not purely cortical but involves the retina also. He and his co-workers have noted that anoxia deepens all suppression phenomena, whereas inhalation of oxygen alleviates them. These effects do not occur only as a result of the inhalation of different gas mixtures; the effect of anoxia can also be produced by compressing the globe, and extra oxygen supplied by subconjunctival injection produces the effect of inhalation of oxygen. Bietti has also found that the instillation of strychnine and certain other drugs into the conjunctival sac has a beneficial effect. The effectiveness of the local application indicated to him a direct action upon the retina. Some of these effects apparently are not transient, and the studies of Bietti may, therefore, open up new possibilities of influencing the sensory abnormalities in strabismus by pharmacologic means.

The evidence that the retina itself is the seat of the inhibitory processes in amblyopia ex anopsia is not conclusive. If the activity of the foveal cones or of a group of foveal cones were depressed, causing a diminution of visual acuity, the retinal threshold to light would necessarily have to be abnormally high. Now, Wald and I[24] have shown that the absolute threshold to light was essentially normal, foveally and peripherally, in cones and rods, and in light and dark adaptation in amblyopic eyes with a vision of 20/200 or less. Since the entire apparatus of simple light perception was thus proved to be normal in these patients, it was apparent that the apparatus of pattern vision must, to some degree, be distinct from that which mediates the other visual functions. It has been found by ablation experiments that pattern vision in subhuman mammals generally requires the cortex, whereas other visual functions appear to be in large measure subcortical. In man there is evidence that all sensory aspects of vision have indispensable cortical components. The experiments of Wald and Burian,[24] however, show that here also some degree of anatomic dissociation of visual functions must exist.

At any rate, these experiments demonstrate that the disability in amblyopia ex anopsia consists of a cortical inhibition of the higher cortical function of pattern vision without notable impairment of the lower cortical function of light perception. The findings which would seem to indicate that the seat of the inhibition is retinal cannot be accepted as conclusive and are open to different interpretations. For example, Harms' observations do not necessarily require that the inhibition be retinal. It is known that cortical centers exist for both dilatation and constriction of the pupils. It may be supposed, therefore, that the cortical inhibition in amblyopia ex anopsia is not confined to visual acuity but extends further to include cortical pupillomotor centers.

It must also be emphasized that the studies on dark adaption reveal an extraordinary ability of the amblyopic eyes to fixate a small light in subdued illumination, whereas fixation was found to be quite unsteady during the clinical examination in ordinary light. This points to a selective inhibition of macular projection affecting pattern vision in bright light, and to the possibility that amblyopia might be particularly associated with vision in bright light. This finding is significant not only from a standpoint of theory but also with regard to possible therapeutic applications.

Keiner[11] agrees that amblyopia ex anopsia is due to cortical inhibition, since the electroretinogram is normal in amblyopic eyes. However, this finding is not really conclusive, since the electroretinogram is a mass response of the retina and a reduction of sensitivity of the macular area would not find expression in a routine electroretinogram.

But direct electrophysiologic evidence for cortical abnormalities in amblopia ex anopsia is obtained from electroencephalographic studies. Watson and I[6] examined 55 patients with amblyopia and found characteristic differences in the electroencephalogram when the normal eye and the amblyopic eye were stimulated alternately by light. The so-called alpha rhythm, a characteristic rhythm of about 10 cps occurring normally in the parieto-occipital region, was always promptly blocked when the normal eye was exposed to stroboscopic light stimulation, whereas the alpha rhythm continued under those circumstances if the amblyopic eye alone was exposed and its acuity was below 20/70. Also, the rhythmic electric activity of the occipital cortex in response to rhythmic illumination of the eyes, known as "photic driving," was less easily produced from amblyopic eyes. When driving was obtained at all by illuminating the amblyopic eye, it was less regular, often occurred momentarily, and was of lower voltage than that obtained by illuminating the normal fellow eye.

Experiments similar to those of Burian and Watson were performed by Parsons-Smith.[18] He stimulated alternately the amblyopic eye and the sound eye of 50 children and recorded the cortical responses. In 34 cases he could not elicit photic driving; in 7 cases the photic driving followed the same pattern, whether the sound eye or the amblyopic eye was stimulated. In 4 cases he found that the alpha rhythm was not suppressed by stimulation of the amblyopic eye; and in 3 cases, in which the patient was known to have seizures, epileptic cortical activity was elicited over the whole cortex when the sound eye was stimulated, but little or no disturbance followed the stimulation of the amblyopic eye.

Parsons-Smith concluded that in certain amblyopic children the light signal received by the amblyopic eye was modified, either by a diffuse cortical lesion directly connected with the affected eye or by a more discrete lesion within the pathways of that eye. In the majority of cases, however, he felt that the visual extinction appeared to be brought about by active cortical suppression.

One last clinical observation points in the same direction. It has been noted that

the visual acuity of amblyopic eyes is regularly higher, often markedly so, when isolated symbols rather than rows of symbols of the same size are used for testing. The crowding of the symbols makes it more difficult for the amblyopic eye to recognize them. As the amblyopia improves, this adverse effect of crowding diminishes. It is difficult to conceive of a purely physiologic optic cause for this behavior of the amblyopic eye, and it is reasonable to assume that it depends on cortical processes.

CONCLUSIONS

1. Amblyopia ex anopsia consists essentially of a loss of pattern vision which is reversible in appropriate cases.

2. Although there is evidence that, in addition to pattern vision, certain macular functions are impaired (increased critical flicker fusion frequency, inverse pupillomotor index), the concept of a congenital amblyopia based on organic (anatomic) anomalies must be rejected.

3. The fact that the entire apparatus of light perception responds normally in amblyopic eyes indicates that the reduction in visual acuity must be due to a selective affection of the apparatus of pattern vision. The seat of this suppression is in cortical structures.

4. To what extent abnormal conditions of sensory stimulation during the years of early development, caused by misalignment of the eyes, may be responsible for the reduction of central vision cannot be decided now. An answer to this question will have to await further studies in animals (controlled early deprivation of visual and other stimuli) and in human infants.

5. Observations indicate that fixation by the amblyopic eye is much better in dim light than in bright light, and that the macular region in these eyes reacts in some respects as does the periphery of normal eyes; these point to an analogy between the behavior of the amblyopic eye and the normal dark-adapted eye.

6. From the point of view of therapy, an investigation of the effect of exercises in subdued light and of the drugs suggested by Bietti should be considered.

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STRABISMUS AMBLYOPIA: INCIDENCE AND CHARACTERISTICS

MAYNARD C. WHEELER, M.D.
NEW YORK, NEW YORK

To make a real contribution to knowledge of the incidence and characteristics of amblyopia as it is related to strabismus would require a detailed analysis of a large series of cases. As this was not possible, I have had to be satisfied with a brief survey of recent literature and a perusal of some of the charts from our eye muscle clinic.

Before we can talk about the incidence of amblyopia in strabismus, we must try to define it in clinical terms. Dr. Burian has given a brilliant discussion of the nature of amblyopia, but how are we to recognize it in a given case?

The literature on the incidence is not very helpful because in most instances amblyopia is not defined. Amblyopia occurs in from 1 to 3 per cent of the general population (table I). In amblyopic individuals, the incidence of strabismus, according to reports by Irvine,[11] Bourquin,[3] and Sugar,[18] ranges from 20 to 41 per cent. The occurrence of amblyopia in persons with strabismus is of more immediate interest to us, but here again only three sets of figures have appeared in the recent literature.[6, 7, 10] These reports are too few and too lacking in definitions to give more than general impressions.

There is fairly general agreement on the definition of strabismus amblyopia. Probably that given in the symposium of the American Academy of Ophthalmology and Otolaryngology in 1953, by Burian,[4] is the most authoritative as it carries the sanction of six experts: "A reduction in visual acuity in one eye which may be reversed by appropriate means and for which no ophthalmoscopically demonstrable cause can be found." Bangerter[1] amplifies this by describing it as a disproportion between visual faculty and expected visual function, that is, there may be a defect in the eye but it is not sufficient to explain the degree of lowering of visual acuity.

But just what degree of lowering of visual acuity is to be called amblyopia? Many articles on this subject make no attempt to answer this question. The symposium[4] settled on 20/40 or less as indication of clinically significant amblyopia; Ramsay,[15] less than 20/20; Bourquin,[3] 20/25; Bangerter,[1] 20/25; McCulloch,[12] 20/40; Costenbader,[6] 20/40 or less; Feldman and Taylor,[9] less than 20/50.

At this point, a few words about the puzzling problem of the testing of visual acuity seems justified. All are agreed that the "E" test is the best available for children who have not learned to read, yet many of us are dissatisfied with this method. It is not uncommon in our clinic, where the testing is done by trained technicians, to have the vision recorded as 20/15 OD, 20/20 OS by the E; and 20/20 OD, 20/50 OS by the letters on the Project-o-chart. The first result would hardly be called

From the Institute of Ophthalmology, Columbia University, New York.

Read at the Annual Joint Meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians, Oct. 9, 1955, Chicago.

TABLE I

INCIDENCE OF AMBLYOPIA

AUTHOR	GROUP	PERCENTAGE AMBLYOPIC
Irvine[11]	10,000 Air Force personnel	1
	5,000 patients receiving glasses	4
Bourquin[3]	34,000 patients	1.3 (20/25)
Nemetz et al.[14]	General population	1 to 2
Hammer[10]	General population	1.5 (strabismus)
Downing[8]	60,000 draftees	1.7
Bangerter[1]	765 children	3 (20/25)

amblyopia or would indicate a highly satisfactory response to treatment, but the second would surely be classed as amblyopia or a poor result. One reason for this, undoubtedly, is that with the E there are only four possibilities each time, but with letters there are 26. Another is that the E's are presented one at a time, but the letters are usually exposed in a line. Bangerter and Muller[13] have emphasized the importance of the inability of people with amblyopia to separate letters. They believe that it is a characteristic of strabismus amblyopia, and they have devised an apparatus for both testing and training this faculty. I feel confident that few will disagree with the statement that accurate measurements of visual acuity are extremely difficult to make, and that at the present time nothing like absolute values can be achieved.

Anyone who has studied many of these cases knows that visual acuity considerably better than 20/40 may accompany monocular strabismus, particularly after treatment. Not infrequently, equal visual acuity will be achieved in the two eyes by treatment, but there will still be a marked preference for the originally fixing eye; and occasionally the originally squinting eye will temporarily actually acquire the better visual acuity without a shift in fixation. So in terms of potential binocular function, merely equalizing the visual acuity of the two eyes is not the goal we seek, and we are unable to answer the question of what degree of lowering of visual acuity constitutes amblyopia.

This raises the second question: Since we have no really satisfactory method of measuring the visual acuity and present methods do not always give reliable information as to which eye is being used, is there any other way that we can get an idea of what is happening? By studying the early cases of strabismus in patients who were too young for visual acuity testing, we have learned that the fixation pattern gives very valuable clues. We know that in a case of solidly monocular squint, there will almost surely be amblyopia of the squinting eye. Also, if there is any alternation, even in only one field, there will be little amblyopia. Applying this to children between 5 and 7 years of age, in whom visual acuity can be fairly accurately measured, we are coming to the conclusion that, in many cases, careful observation of the binocular fixation pattern may give a more accurate evaluation of amblyopia than the record of vision. Furthermore, the fixation pattern is just as important for maintaining the best visual status attained as is the actual visual acuity.

When we are confronted with a case of strabismus of low degree, particularly after operation, in which there is little or no difference in visual acuity, a marked preference for one eye warns us of future visual deterioration. Again, in the course

of occlusion treatment, the visual acuity may improve at each visit until the two eyes are equal, but if there is still a definite preference for the originally fixing eye, our objective has not been achieved. As ophthalmologists, we are vitally concerned with visual acuity; but as orthoptists and muscle enthusiasts, we are also interested in it as a prerequisite to normal binocular vision. Since we feel that our present methods fail to measure visual acuity with sufficient accuracy to tell us what we need to know, that is, which eye is being used and to what extent, we suggest that we may gain more information of what is actually happening by study of the binocular fixation pattern.

Even this is not an easy solution to the problem. Observations of the binocular fixation pattern may be extremely difficult to make with certainty, particularly when the child is young and when the deviation is small. At one extreme we have the patient with solidly monocular strabismus which is usually accompanied by amblyopia; at the other extreme is the spontaneous alternator who is just as surely not amblyopic. In between these extremes are various gradations that present various degrees of difficulty. In our clinic we have tried to grade them into slight, moderate and marked preference, depending on the rapidity with which fixation is resumed by the preferred eye after it has been uncovered, but these are difficult to define so that all will agree. In fact, we frequently disagree on this observation, so as yet we do not have the complete solution for which we are searching.

In judging the preference for fixation, there is obviously no certain road to a positive answer in many cases. It must be studied for both distance and near and in the six cardinal directions. We rely heavily on the cover-uncover test. The type of fixation object is of great importance, particularly for near because a light may produce a different response than a small picture with fine details. The examiner must exert continuous vigilance to observe the slightest shift and to make sure that the patient is trying to fix and not staring. Even so, there are many instances when we are in doubt.

With these ideas in mind, and with the skilled help of the young ladies in our orthoptic department, we analyzed 235 charts of amblyopic patients. These patients had 20/40 vision or less in the squinting eye, more than one line difference in visual acuity between the eyes or a definite preference of fixation with one eye. Of these there were 181 patients with convergent strabismus who received some sort of treatment for amblyopia. These patients are of the greatest interest for this discussion and are divided into 6 groups.

Results of Treatment in Cases of Amblyopia with Convergent Strabismus

A. Failure to get 20/40 in the amblyopic eye, 26 cases

B. Visual improvement but no change in fixation pattern:
   Visual acuity 20/30 in amblyopic eye but 20/15 in fixing eye, 10 cases
   One line difference in visual acuity between the 2 eyes, 31 cases
   Equal visual acuity in the 2 eyes or 20/20 in amblyopic eye, 38 cases

C. Change from fixation to only a preference in the fixing eye:
   Two lines difference in visual acuity, 2 cases
   One line difference in visual acuity, 17 cases
   Equal visual acuity in two eyes or 20/20 in squinting eye, 32 cases

D. Equal or better visual acuity in originally squinting eye and fixation with this eye, 12 cases

E. Better visual acuity in squinting eye but no change in fixation, 9 cases

F. Better visual acuity in originally fixing eye but squinting eye preferred, 4 cases

The first group of 26 cases (A) are those who failed to attain 20/40 vision in the amblyopic eye and would be considered failures by almost everyone.

The second group (B) is made up of 79 cases that showed a fairly satisfactory improvement in vision (better than 20/40) but no change in the fixation pattern. Many authors (including myself in 1949) would have called these therapeutic successes but we now are dubious about them.

In the third group (C), 51 cases showed an improvement in the fixation pattern, usually from monocular fixation to a preference for the same eye. We are inclined to consider this more important than the greater visual improvement achieved when there was no change in the fixation pattern (B). I am sorry that I do not have sufficient data on the binocular status of this group to prove our belief that these children have a better chance of developing binocular vision and of maintaining the best visual acuity attained than those who had no change in the fixation pattern.

The fourth group (D), 12 cases, is one that should provoke little discussion because the visual acuity was either equal or better in the originally squinting eye and the preference of fixation was shifted to this eye. I believe that we would all call these successes.

Nine patients (E) had better visual acuity in the squinting eye but no change of fixation. It has been suggested that dominance may explain this result, but I know of no way to prove it. Nancy Capobianco has shown that some of these patients are unable to shift fixation voluntarily although by the cover-uncover test they fixate monocularly.

Finally there were 4 patients (F) who still had better visual acuity in the originally fixing eye but preferred the originally squinting eye. These results are difficult to explain.

Characteristics of Strabismus Amblyopia

I will now try to summarize the characteristics of strabismus amblyopia. Most authors agree that there is greater frequency of amblyopia with constant and monocular deviations than with other types of strabismus. Yet Bangerter makes the surprising statement that amblyopia with strabismus occurs equally in alternating and unilateral cases.

Bangerter found no relation between the degree of deviation and amblyopia.

The majority of authors have stated that the earlier the onset, the greater the probability of amblyopia, but the findings of Costenbader and Scobee [17] indicate that this may not be true. These findings need more study, as they seem to contradict some of our basic ideas about amblyopia.

Most writers agree that the incidence of amblyopia is greater in convergent strabismus than in divergent strabismus.

We divide the cases of monocular strabismus into four groups depending on the type of fixation in the deviating eye: (1) fixation good and central: these present no particular problems; (2) grossly eccentric: we have been unsuccessful in treating these; (3) roving: these are difficult but are not hopeless and frequently show rapid improvement, and (4) questionably eccentric: these probably should be given a short trial on occlusion but unless there is prompt improvement some form of binocular treatment is advised.

In 1948 Costenbader[6] emphasized the importance of studying monocular fixation and suggested that visual acuity be determined by ability in foveal fixation. He divided 222 cases into three groups: (1) good and central fixation (178 eyes, 20/15 to 20/200, average 20/34); (2) poor (unsteady) but central fixation (31 eyes, 20/30 to 20/1000, average 20/165); and (3) eccentric or roving fixation (13 eyes, 20/200 to 20/1400, average 20/573).

Roenne[16] is apparently thinking along similar lines when he reports 270 cases of amblyopia in children, divided as follows: (1) serious amblyopia with vision of less than 3/60 and uncertain or eccentric fixation, 61 cases; (2) central fixation but vision 6/60 or less, 64 cases, and (3) 6/36 to 6/18, 100 cases.

Eccentric fixation is a subject that is receiving increasing attention in the literature from Europe, most notably by Bangerter, who is offering a constructive approach to these cases. However, grossly eccentric fixation is rare in our experience, and possibly because we have been unable to employ Bangerter's methods, we have been unsuccessful in treating it.

A great deal has been written about the type of scotomas found with amblyopia, but as this has little practical value in the majority of our young patients, it will not be discussed.

Anisometropia undoubtedly plays an important part in the etiology and the treatment of amblyopia. Campbell[5] found anisometropia and hypermetropia to be the primary factors in the incidence of amblyopia, and Costenbader agrees. Sugar's is the one dissenting voice in this controversy.[19]

We studied the refractive errors in our 181 cases of amblyopia with convergent strabismus. Only the groups A, B and C of our classification, (p. 15), comprising 156 cases, were large enough to be significant. These figures would probably mean much more if we had a comparable group of nonamblyopic cases, but a few points may be worth noting. Spherical equivalents were used to give a single figure for the total refractive error. Fifty-eight cases (37 per cent) had a total error of +4 diopters or more in each eye. Fourteen of these cases failed to respond to treatment, and 23 remained monocular fixators. We were surprised to find only five cases with an anisometropia of +1.5 diopters or more. Two of these were therapeutic failures and the other three remained monocular fixators. When 1.0 dipter or more of anisometropia was taken as the criterion, we found 35 cases, of which 12 were failures and 12 more remained monocular fixators. Four cases revealed antimetropia with the amblyopic eye having myopia; 3 of these cases were failures and the other remained monocular. Drawing conclusions from such limited material without more detailed knowledge of other factors is little better than pure conjecture. However, it seems safe to state that an anisometropia of at least 1.5 diopters and antimetropia are serious obstacles to achieving binocularity.

The possibility of having amblyopia superimposed upon an organic lesion has been suggested by Bangerter and Costenbader. (Here Bangerter's definition of amblyopia is useful.) It seems logical that it could occur, and if recognized early enough, the amblyopia should be susceptible to treatment. However, the underlying pathologic condition would still be present and in all probability would continue to be an obstacle to binocular vision. In our series there was no recognized example of this.

SUMMARY

It should be apparent that I have raised several questions and failed to answer them. My hope is that others may be stimulated to continue the search for the answers.

Most of us have always thought of amblyopia primarily in terms of visual acuity and secondarily as an obstacle to binocular vision. I am suggesting that amblyopia is important as an indication of absence of function and that the measurement of visual acuity has been inadequate in many cases. The study of the monocular fixation pattern gives important information concerning the type of treatment to be employed and the prognosis for attainment of normal visual acuity. The study of the

binocular fixation pattern is important in the detection of amblyopia and in the maintenance of the visual acuity achieved by treatment.

In evaluating the results of treatment of amblyopia, one must consider first the immediate improvement in visual acuity. This gives evidence of the success of occlusion and certainly encourages the parents. If visual acuity is improved without alteration of the fixation pattern, it may recede, but it is always recoverable. To ensure a permanent improvement, there must be a shift in the fixation pattern.

So our goal is a shift in the fixation, for with alternation, visual acuity in each eye will be maintained. We believe that this will give a more symmetrical result, will increase the chance of a functional cure, and will ensure satisfied parents even though the cosmetic improvement is slight.

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Symposium: Amblyopia

THE TREATMENT OF AMBLYOPIA

FRANCES FOWLER, O. T.
LOS ANGELES, CALIFORNIA

IT was two hundred years ago in Paris that duBuffon wrote: "It seems to me that the simplest, most natural and perhaps most efficacious of all methods (of remedying a squint) is to cover the good eye for a time. The deviating eye will be obliged to work and to turn itself towards the object, and soon this movement will become habitual. . . . In all the experiments I have made I have found that the squinting eye, which is always the weaker, acquires strength through exercise."[14]

This is as true today. But today, we know that strengthening the weaker eye is not enough. The vision in the amblyopic eye must be made equal to the vision in the good eye. Moreover, treatment must be continued until the child no longer prefers to fixate with his originally good eye, but alternates fixation freely. If this spontaneous alternation of fixation does not occur and the child continues to fixate with one eye habitually, the vision which has been so carefully developed will be actively suppressed, and all the effort will have been wasted. Furthermore, good vision in each eye and the resultant good fixation are necessary prerequisites to a functional binocular result. If amblyopia is corrected and fusional amplitudes are established before surgery, the strabismic patient will almost certainly have single binocular vision after surgery. This will not only ensure that vision will not deteriorate again but it will also prevent a secondary deviation from occurring.

I believe that *occlusion of the good eye should be constant and total* and that it should be continued until vision is equal and alternation of fixation is obtained.

The objections to total occlusion which might be made are few, and I will deal with them later. The objections to partial occlusion are now recognized. Scobee[20] disagreed with the use of atropine for occlusion, admitting that it forces use of the amblyopic eye at near, but the distant object of regard is only slightly blurred, while the image seen by the amblyopic eye is even more blurred. Therefore atropine was equal to and no better than part-time occlusion. Duke-Elder felt that atropine, varnish on the lens, etc., should be used only when fusion occurs with the eyes in the parallel position, e.g., in accommodative strabismus with glasses. Otherwise the development or consolidation of anomalous correspondence is invited. Partial occlusion can be useful, when the maximum visual acuity has been attained and the eyes are straight, to ensure that amblyopia does not recur.[5]

How early should orthoptic treatment be started? Wheeler, reviewing the literature in 1950, found that the trend was towards starting treatment earlier and carrying on longer.[3] Wheeler pointed out that we can assume that if a youngster uses one eye habitually, the deviating eye will be amblyopic.[25] Amblyopia can therefore be recognized, and cured, at an age well

From the Department of Ophthalmology, The University of California at Los Angeles Medical School.

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below the age required for determining visual acuity with E's or pictures. As an orthoptist, I agree thoroughly with this. Tiny babies, less than a year old, are sent to our clinic, and by playing with them in a very few minutes we can find out which is the fixating eye, whether alternation ever occurs in any field, and finally, if one eye is habitually turned, whether there is central fixation. The babies seem hardly to notice when an occluder is placed on the fixating eye. We let them handle toys; sometimes their reaction to a colored or flashing light will give the first indication of central fixation in the habitually turned eye. When fixation is poor, it usually improves after two or three days of occlusion. Transference of fixation to the other eye may occur very quickly; therefore, there should be only a few days interval between checks.

If amblyopia is recognized as a probable complication of strabismus in an infant, the treatment of strabismus can be said to be the prevention of amblyopia. Duke-Elder speaks of the maintenance rather than the restoration of equality of vision in the two eyes. "If equality of vision is maintained in the two eyes by alternate occlusion if necessary, much of the labor and most of the disappointments of subsequent treatment will have been saved."[5]

In children under three years of age, occlusion is done routinely before surgery. In the older children, there is also much to be said for preoperative occlusion. Duke-Elder states that even in adolescents it is wise to begin exercises so that the elements of binocular vision can be established, if possible, before the eyes are straightened.[5] Wheeler notes that prior to the emotional upset due to surgery, it is advantageous to have occlusion already completed.[25] Moreover, strabismus may recur during postoperative occlusion. From the orthoptist's point of view, the diplopia in casual seeing and the fusional amplitudes on instruments, which the child has achieved whose occlusion and preoperative orthoptic treatment are already completed, are her greatest tool in overcoming any small remaining postoperative deviation while it remains small.

How long should treatment be continued if there is little or no improvement or if improvement has slowed down?

Wheeler stops treatment if there is no further gain after two to four weeks;[25] Jackson continues for three to six months after the last improvement is noted.[11] Enos[7] and Jackson[11] pointed out that the near visual acuity may be improving at a rate much quicker than distance vision, and that near visual acuity should be tested at the beginning of patching, and retested during occlusion. I like to continue occlusion until there has been no improvement at either distance or near for at least six weeks.

There is one group of patients with amblyopia which cannot respond to total occlusion of the good eye. These are children with eccentric fixation. In eccentric fixation, when the normally fixating eye is covered, the deviating eye takes up a definite eccentric fixation. There are two possible causes. The first is a macular lesion. The second is that the macula is so strongly inhibited that an eccentric point on the surrounding retinal area is chosen for fixation. In these cases, Duke-Elder says that the direction of shift is the same as that of the strabismus, but the angle between the optic axis and the axis of fixation remains at about 8 to 10 degrees.[5] The eccentric fixation area never attains a greater visual acuity than that particular retinal area is capable of, usually less than 20/200. The anatomic macula has, of course, a still lower acuity.

This last group of cases may respond to treatment, and treatment has been described as successful by Bangerter[17] in

Switzerland, Fritz in France,[9] Bagshaw[2] in England, and Swan[21] and Swenson[23] in the United States.

I started working with such patients in 1942. We do not attempt to improve the visual acuity of the eccentrically fixating eye, but we have been able to establish a form of stable binocular vision, with peripheral fusion, in spite of the low acuity of the amblyopic eye.

First, we totally occlude the deviating eye. It is useless to occlude the fixating eye, since that could only stimulate the eccentric fixation to its maximum visual acuity, which is far below that of the normal macula. The duration of occlusion of the deviating eye varies from three months to nearly a year. At the time when fixation of the amblyopic eye appears to be no longer definitely eccentric but merely wandering, we substitute a three-quarters temporal occlusion of the amblyopic eye, leaving the nasal quarter uncovered so that light is able to stimulate the macula and temporal retina, but not the eccentric fixation area. At this time orthoptic treatment is started. The patient is allowed to fixate a small target in the major amblyoscope with his good eye, and a large square or circle is gently oscillated so that the image surrounds the macular area of the deviating eye. This procedure is alternated with the use of peripheral stereopsis targets. As soon as some fusion is demonstrated with either type of target, the patient is immediately returned to the ophthalmologist for consideration of surgery. In the 4 cases (1942), which I was able to recheck, the eyes of all four patients had remained straight throughout the four years after surgery, and all continued to demonstrate peripheral fusion on the major amblyoscope (figs. 1, 2 and 3).

Let us return to the treatment of the large group of cases of strabismic amblyopia with central fixation. Total occlusion of the good eye does not necessarily result in restoration of vision in the amblyopic eye. Mary Kramer[16] points out that during occlusion there may be an indifference and visual inefficiency; a child may describe objects seen in the distance yet not see them with any accuracy. While occlusion *may* arouse a desire for definitive vision, often it takes positive well-directed treatment to stimulate the child to make the effort to attain normal vision.

Suggestions for monocular stimulation have been made by so many of you that I will repeat them only briefly:

Television is a boon. Newspaper headlines for those who can read, bead stringing, wool embroidery, coloring, and jigsaw puzzles are a few of myriads of ideas which will occur to both orthoptist and mother. But surely the occupation should be a pleasure for the child. Find out what the child's hobby is. Reading for a child who loves to read is more efficacious than bead stringing, provided he is given intelligent help at the beginning in discovering what size of print he can manage, and is pushed gently but firmly into reading smaller print and continuing his reading over longer periods.

When the patient's mother has little time, an older brother or sister can do wonders. The father should always come to the doctor's office and orthoptic clinic at least once. Not only can he be persuaded to help by an eager doctor or orthoptist, but also, he will stop adding to the family worry by asking "what it's all about, anyway."

For the child of three years of age and over, what, if any, are the advantages of beginning orthoptic treatment before vision is equal and fixation is alternating?

I think that they are several and important, and that they are based on accepted theory.

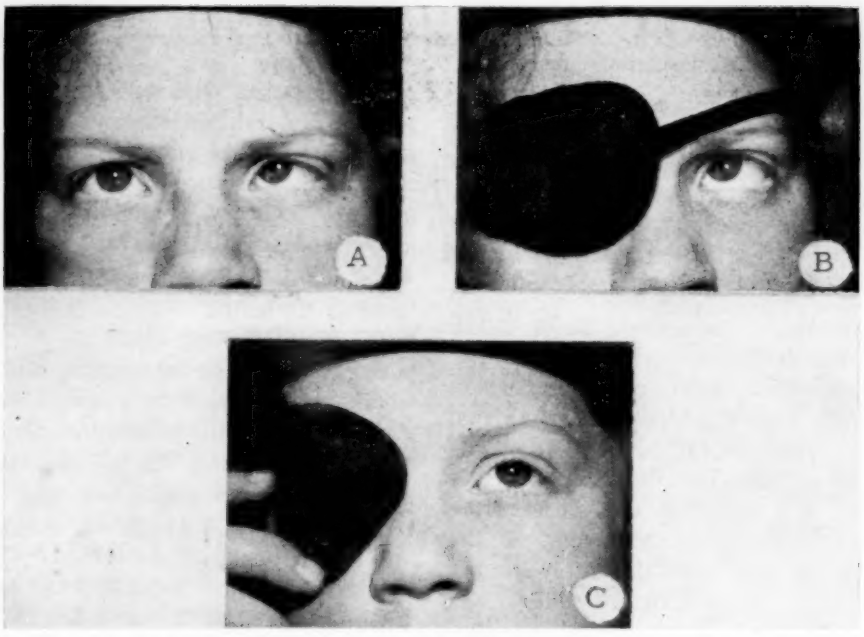

FIG. 1—M. J. (A and B) Left esotropia with eccentric fixation, June 1943. (C) Central fixation after surgery and orthoptic training, November 1943.

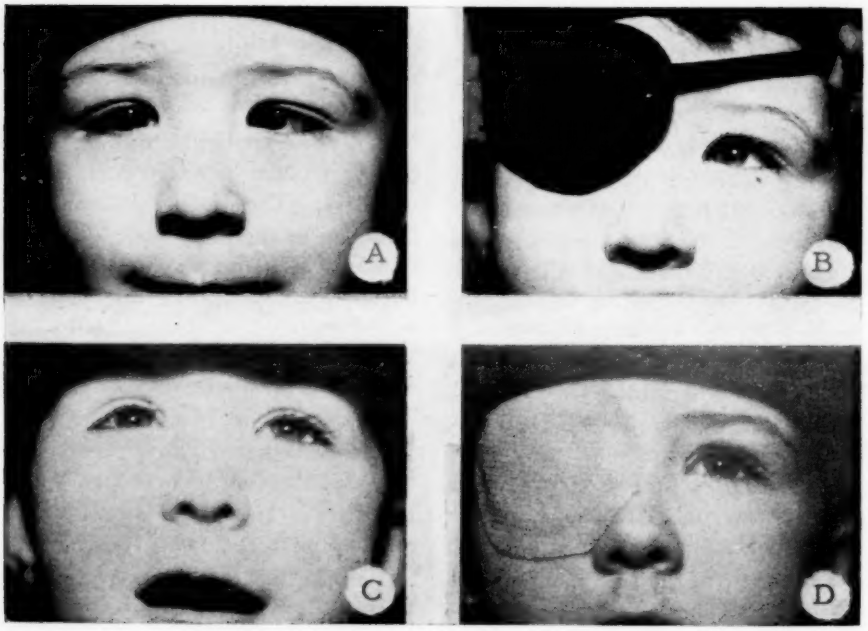

FIG. 2—T. McI. (A and B) Left esotropia with eccentric fixation. (C and D) Central fixation after surgery and orthoptic training, 1946.

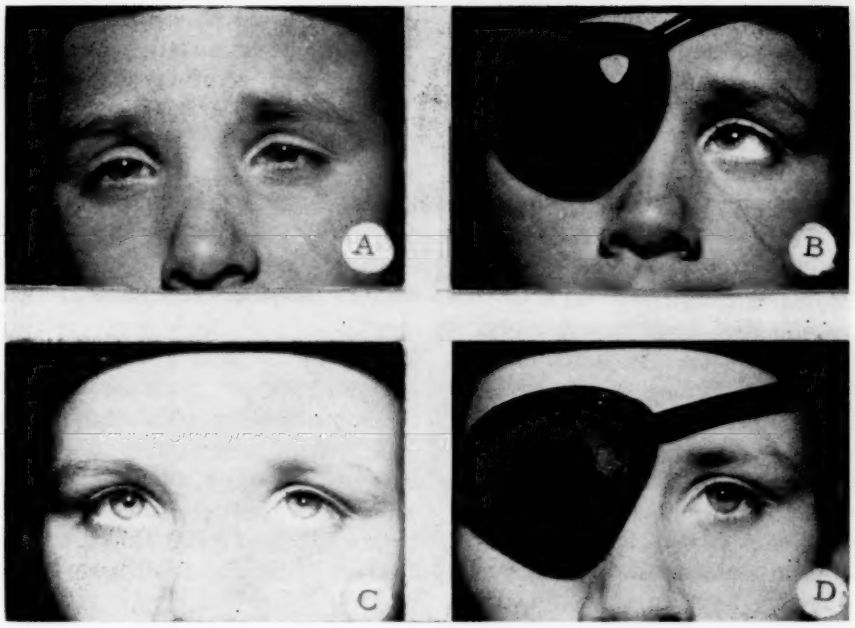

FIG. 3—L. T. (A and B) Left esotropia with eccentric fixation, March 1942. (C and D) Eyes straight, central fixation, three years after surgery and orthoptic training, 1945.

First, orthoptic treatment is an encouragement to both mother and child, so that occlusion is more likely to be persisted in.

Second, and more important, orthoptics brings the child to optimum ocular condition for surgery simultaneously with the optimum time for surgery.

Finally, and most important of all, orthoptics can shorten the patching period which has already been a hardship. I shall discuss each point in turn.

Oaks[18] points out the value of frequent visits in order to evaluate progress, to change activities, and most of all, to make clear the doctor's or orthoptist's interest in the outcome. When we see a child once a week, and find a line of vision improvement, our pleasure and encouragement are a tremendous incentive for further effort.

The ideal time for surgery, from the orthoptist's point of view, is immediately upon attainment of equal vision, normal retinal correspondence and recognition of diplopia. Some children begin to recognize diplopia during the few seconds in which the patch is being changed when the vision is as low as 20/50. These children as a rule have normal correspondence, seem to alternate out of curiosity and experimentation before the vision is equal, and are ready for surgery as soon as vision is equal. If other children could obtain these same results, from a minimum amount of orthoptic work during the last few weeks of occlusion, they could be ready for surgery immediately after vision is equal.

We have treated a third and smaller group who have anomalous correspondence and amblyopia from the beginning of the patching period, in an attempt to establish at least a minimum peripheral fusion response before surgery, without postponing the date of surgery.

Of course, this orthoptic training could be done after the vision is equal and before surgery, but I feel that this unnecessarily delays the surgery and prolongs the patching period.

But apart from encouragement, visual

acuity checks, and the establishment of normal retinal correspondence and fusion, I believe that the actual length of time required to establish equal vision with occlusion alone can be shortened with orthoptics. Orthoptic treatment of amblyopia is appropriate because functional amblyopia can be demonstrated to be accompanied by suppression.

Wald and Burian state that both lack of attention and suppression occur in patients with strabismus, and that they represent exaggerations of physiological processes.[24] Duke-Elder says that in the majority of squinting cases, there is added to the amblyopia of arrest an active inhibition suppressing vision already developed.[5] Feldman says that "just the attainment of normal vision in an amblyopic eye is not sufficient. The permanency of good visual acuity is assured only when . . . fusion with amplitude is gained."[8] Keiner suggests that the high visual acuity of the macula can be achieved only by the exercise of the relevant optomotor reflexes: the fixation and the fusion reflexes.[15]

Orthoptics provides a method of counteracting both the amblyopia and the suppression simultaneously. The active act of concentration required to see, then fuse, targets in the major amblyoscope is an exercise in perception for the amblyopic eye which cannot be duplicated by monocular practice when the good eye is occluded.

It is often suggested that in attempting to eliminate suppression of the image of the amblyopic eye while it is being used with the good eye, the light should be dimmed in front of the good eye and increased in front of the amblyopic eye. Mary Pugh,[19] for example, found that stereoscopic targets could be seen centered, and stereoscopically, by 50 per cent of patients with amblyopia, provided the illumination was decreased before the good eye, often as much as 1/1000.

On the other hand, a number of my older and more articulate patients have complained that when this was done the inequality of illumination was more annoying than helpful; a difference in color quality was noted, and some insisted that the inequality of illumination simply made two similar or stereoscopic targets more unlike and impossible to fuse.

If after further study this appears to be true in a larger number of cases, it would seem to have some relation to Duke-Elder's statement that in amblyopic vision the apparatus subserving form suffers, particularly in bright light.[5] Wald and Burian found that a selective inhibition of the macular area affected pattern vision principally in bright light and left it almost unchanged in dim light.[24] Irvine suggested devising a series of brief successive visual stimuli associated with auditory or kinesthetic stimuli to improve the fixation reflex, the test to be done under dark adaptation, based on findings of Burian and Wald that fixation is relatively good even in severe amblyopia in the dark-adapted eye.[10]

On the other hand, I have always found an exceedingly small oscillation of the target before the amblyopic eye to be very useful, often obtaining simultaneous perception without suppression, and stereopsis with ring targets after a few minutes of stimulation.

I generally present the target which is to be shown to the amblyopic eye to that eye first; then if detail is not well perceived, to the good eye and then again to the amblyopic eye. The amount of perception and the amount of memory cannot be differentiated, but with small children, using slides with much detail, it seems possible that some increase in visual perception is a part of the increase in total awareness. Also, sustained interest is important in eliminating suppression, and when the visual acuity is so low that the targets are difficult to recognize as a picture, the increase in interest when the

target has been shown briefly to the good eye is worth obtaining even if the increased perception should be shown to be based entirely on memory.

I should like to emphasize the importance of regular checks even after the goal of equal vision and single binocular vision has been obtained. Costenbader finds that by the age of eight, the improvement stabilizes and needs less attention.[4]

The objections to total occlusion which might be made are few. They are the following:

1. Loss of vision in the good eye
2. Skin irritation from a patch adhesive to the face
3. Possible occurrence of strabismus for the first time when total occlusion is done on a child with straight eyes
4. Incapacitation of the child for every day living
5. Emotional disturbance

I shall attempt to deal with each objection in turn.

First, a line or more of vision may be lost in the covered eye in a very young child, but the vision returns quickly with alternate patching. This loss in the covered eye, about which the mother is often fearful, is better prevented than corrected. Therefore, for patients under four years of age, a weekly visit is advisable. This need be no more than a check by the doctor or his orthoptist as to which eye is fixating after a few moments without the patch.

Second, we have prevented skin irritation by cutting the elastoplast patch a slightly different shape and sloping it in a different direction at each change. In cases in which the skin nevertheless becomes sensitive we cut a large total patch of elastoplast to fit over both sides of the lens before the good eye and extend it well over the nose piece and temple so that no light can enter, with specific instruction that this is a temporary expedient for the two or three days it takes for the skin to heal before returning to the face patch. If the child wears no glasses we occlude the appropriate side over a pair of empty frames.

The elastoplast over the glasses fits smoothly against the face, and is much more peekproof than any of the commercial occludors which are designed to clip on glasses.

The third objection is the possibility of convergent strabismus occurring as a result of occlusion in children whose eyes have always appeared "straight." The visual acuity in the amblyopic eye is often as low as 20/200. I have seen a few cases of convergent strabismus following occlusion. Swan reported on several cases.[21] I believe that this possibility is sufficiently likely that it would be well worthwhile to warn the parents of every such child before occlusion that strabismus, correctable by surgery, may ensue. I think that in such a case with a weak peripheral fusion hold (though not too weak to have held the eyes straight in spite of amblyopia) the contraindications to partial occlusion do not apply. Here is the occasion for using sufficient varnish on the glasses to reduce the visual acuity of the good eye slightly below that of the amblyopic eye. The necessary amount of blurring must be determined at least weekly. These children have normal correspondence and all three grades of fusion can be demonstrated, provided that the targets of the major amblyoscope are large enough to encompass the suppression area. Here then is a place for orthoptics from the beginning of occlusion. The slightest esophoria or esotropia can be counteracted immediately with fusional divergence, using peripheral targets. Physiological diplopia can be recognized even when central vision in one eye is still very low, and this can be used as a tool to ensure that binocular vision is not lost in the process of restoring visual acuity.

The fourth objection to total occlusion, incapacitation of the child, is a real prob-

lem. The mother says in despair, "My child won't see at school; he won't be able to play out of doors or cross the street; the teacher will object; he'll get behind in school." The cooperation of the teacher is needed here, and a letter from the doctor or orthoptist is often of value. Some teachers will excuse the child with a patch from the finer work or even from routine work, whereas we want the child to make an additional seeing effort and to try to keep up with school tasks, although it should be expected that his work will not be as expert as before occlusion. Holger Ehlers,[6] in Chicago in 1952, pointed out that the visual acuity of an amblyopic eye does not indicate the same degree of disability as the same visual acuity found in an eye with organic disease. Also, we know that neither light sense nor color sense nor the field of vision is affected, but only form or pattern vision. However, we do suggest that the child should not be allowed on the street alone for the first few days, and we supplement this suggestion with a little warning card given to the mother at the time occlusion is first applied:

WARNING

The eye with the better vision has been covered in order to encourage use of the eye with the poor vision. Please be sure that the child is accompanied when he is on the street.

Finally, the intense emotion and rebellion of some youngsters may itself be a sign that the child has a pathologic amblyopia. Wheeler suggests that we give these children the benefit of the doubt.[25] Janus warns against prolonging occlusion on a child with a nervous temperament who is becoming unmanageable, and finds that in these cases occlusion often fails to overcome the amblyopia even when it is continued persistently.[13] In practice, however, I have found that when the first sign of improvement in visual acuity can be demonstrated to both parent and child, any emotional difficulty is completely counteracted. The day the patch is applied, I draw a small rough likeness of the "E" chart with a big tick beside the E's that the child has been able to recognize and give it to the child. I ask him to bring it back the next week to see how many smaller E's on the clinic chart he will see, so that we can bring his little chart up to date. I have found that this provides more motivation and reward than does membership in a Patch Club or Pirate's Club, which seems to emphasize the patch rather than the improvement.

A form of therapy not yet confirmed elsewhere is being done by Bangerter in Switzerland.[17] Occlusion is not done, but daily visits of several hours are required. His apparent successes seem to indicate that active effort to see is a part of the restoration of vision, and surely we should be able to combine some of his methods with total occlusion for quicker results. His combination of visual stimulation with touch and use of hands, with memory, or with hearing is psychologically sound. One of his instruments, modeled on a Maddox cheiroscope, with which the child traces the picture seen reflected on a paper, was fitted by him with an arrangement whereby a bell rings each time that the pencil slips off the line. Our American children might slip off the line on purpose to hear the bell. Another instrument is based on the observation, which we have all made, that an amblyopic eye can read a single letter of a size that cannot be recognized when it is combined in a line of print. In his instrument, E's or other letters are guided by the patient with strings, and can be moved nearer together until recognition fails, or farther apart until recognition occurs. Another instrument, utilizing memory, allows a recognized letter to be receded from a child's eye until it is unrecognizable and then brought forward just enough for recognition and then receded again. This results in apparently remarkable increase in visual

acuity when the child is retested with an ordinary Snellen chart after a half hour of practice.

Diagnosis, determination of prognosis, and treatment of amblyopia in the child under three years of age are almost synonymous; one can separate the incurable group only by a trial period of complete occlusion. There is, however, a place for some other method of determining a prognosis for restoring vision in an amblyopic eye in an older child.

Jaffe and Brock use the principle of the afterimage test to determine whether the fovea of the amblyopic eye is used for fixation, or whether there is actually a slight eccentric fixation.[12] I have tried their method on older children with and without amblyopia, and with and without single binocular vision, and find myself unable to elicit transfer of an afterimage from one eye to another in a great number of children. Though I feel that many more children would be successful after several trials, I would be unwilling to give a poor prognosis for increasing vision in an amblyopic eye solely on the basis of the afterimage transfer test without the period of trial occlusion.

Adler states categorically than an amblyopic eye may recover the amount of vision which it had before the inhibition occurred, but that it never can acquire vision which it had not developed.[1] If this is so, then a careful history would help to determine whether and how long to treat. Keiner, however, said that his cases did not support this opinion and maintained that the time at which amblyopia began, not the age at which treatment is started, is the decisive factor.[15]

Janus suggests that when the research on effects of occlusion on electroretinograms has been completed, we may have a reliable guide to the benefit which may be expected from continued treatment in difficult cases.[13]

I have used the telescopic spectacles for many years to establish prognosis. Usually this reveals one or two lines only of improvement over the existing visual acuity; when however, after occlusion, the visual acuity has improved that one or two lines, in most cases the telescope again reveals a further two lines. I do not believe that I have ever found that vision failed to improve if there was an improvement of two lines with the telescopic spectacle.

In summary, I should like to emphasize the importance of total and constant occlusion, along with concurrent orthoptic antisuppression and fusion therapy. All this shortens the presurgical period and enables one to obtain immediate postoperative single binocular vision.

Let us remember that success also depends on the mothers and fathers. Knowledge and understanding of the problem by the parents is the greatest single aid to treatment of amblyopia. Since it is the ophthalmologist who decides whether occlusion and orthoptic treatment is to be given, and since it is he whom parents have chosen for direction and advice, I would like for our ophthalmologists to tell the parents much more than that the eye is lazy, and needs a patch and some exercise.

I think that if parents were told the following facts, they could readily understand:

1. Loss of vision is due to an active process of suppression, not just to disuse, and therefore a period without the patch results in partial or total loss of what has already been gained.

2. Occlusion will be continued even after the vision is equal if the child is not yet alternating.

3. Even if the child achieves alternation, he may have to be taught to use both eyes together.

4. Occlusion does nothing more than restore the vision in the poor eye; the deviation may increase, but the surgical correction of 20 degrees of deviation is not more difficult than that of 15 degrees; the deviation may decrease, but any remaining deviation, even though smaller, may still require surgery.

5. Amblyopia can and does recur if the child is not watched until he is about eight years old to see that vision remains binocular and equal.

6. The treatment of amblyopia may seem long, but it is tremendously worth while, and completely successful in the great majority of cases.

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SUMMARY

WILLIAM E. KREWSON, III, M.D.
PHILADELPHIA, PENNSYLVANIA

A VERY erudite discussion on the subject of amblyopia has been presented. I have no intension of adding to this; however, I should like to crystallize some of the material.

Amblyopia appears to be the consequence rather than the cause of strabismus. It is functional in nature and not due to an organic or anatomical defect. The seat of the disturbance is not known; it might be said, however, that possibly this is located in the retinal neurone, and it may be an extension of a disturbance of higher structures in the central nervous system. It is certain that in amblyopia there is inhibition of the higher cortical function of pattern vision and no impairment of the lower cortical function of light perception. The behavior of the amblyopic eye in dim light has been shown to be similar in some respects to that of the normal eye under dark adaptation. The significance of this and other observations is not yet clear.

Amblyopia, an obstruction to binocular vision, is measured clinically as reduction in visual acuity, and this under certain circumstances and by appropriate means can be reversed. Its occurrence in relation to strabismus is well recognized, but the incidence and criteria for comparison varies considerably in the series of reported cases. However, attention to the fixation habits of the patient rather than to the visual acuity may serve as a more reliable means of evaluating treatment. The goal should be the establishment of a preference for fixation in the originally squinting eye. Anisometropia and hypermetropia are also related to the etiology of amblyopia, but the importance of the relationship is still unknown.

In the matter of therapy the establishment of good vision in each eye is the first step and is of prime importance in the subsequent treatment of strabismus. Occlusion of the better eye, although it is objectionable in some cases, is the accepted practice. The trend in treatment is to start earlier and continue longer. The type and duration of occlusion is determined by the intensity of the amblyopia and the rate of improvement, but both preoperative and postoperative use of occlusion is desirable. Monocular stimulation of the amblyopic eye may be accomplished by various techniques, and the value of some is universally recognized while that of others is unproved. Finally, the treatment of amblyopia must be regarded as a part of the general treatment of disturbances of binocular vision.

From the Department of Ophthalmology, Graduate School of Medicine, University of Pennsylvania.

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THE NATURE OF THE FUSIONAL PROCESS

RUTH WAHLGREN, O.T.
KENNETH C. SWAN, M.D.
PORTLAND, OREGON

IT is our purpose to present a concept of the nature of normal binocular vision. We must understand the normal in order to have a basis for understanding the abnormal, or strabismic, patient. All children with the common heterotropias of childhood still have some of the components of normal binocular vision. Some of the other components may be absent, deficient, or deviated from the normal. When we examine patients with strabismus our aim is to determine how their binocular vision differs from the normal.

Normal binocular vision has sensory and motor components. We shall consider the sensory system first, remembering that the motor system functions in its service. Proper alignment and motor coordination of the two eyes is possible only when the fusional mechanism is functioning normally.

There is much that we do not know about the fusional process; but in most patients with strabismus we can determine the potentialities for the sensory act of fusion, and we can direct treatment accordingly. What is meant by fusion, and what factors in the visual mechanism are necessary for its occurrence?

Fusion may be defined as a cerebral integration of light sensations from the two eyes into a single visual perception. The terms "light sensations" and "visual perceptions" must also be defined.

A sensation is the type of specific sensory response which always results from stimulation of sensory end organs, such as the cones of the retina. Light, sound, heat, cold and pain are other examples of sensation. An awareness of these sensations requires a concentration of attention. An interpretation of their origin and nature requires thought processes. This mental activity which is concerned with sensations is said to be preceptual. Stated in another way, a perception is a mental impression based upon sensations which have reached consciousness and stimulated thought. Assume, for example, that rays of light from an object in space stimulate the retina. Light sensations are created but the individual visualizes them as an object rather than as a source of light. On the basis of light sensations and the use of thought processes, he is able to identify the object, localize it in space, and appreciate its size, motion, color, contour and other features. Fusion is this type of perceptual process. In the fusional process, light sensations from the two eyes are subconsciously integrated and form the basis for a superior type of visual perception. Stated in another way, fusion is a perceptual process which gives rise to visual perception which adds features to binocular vision which are lacking in strabismus.

In order to understand the perceptual process of fusion and its prerequisites we must review the nature of visual sensations, how they arise, and how they are integrated.

Light is the normal stimulus to vision. The light stimulus to the retina may vary in intensity, duration, frequency, hue, pattern, and the direction from which it originates. Each of these physical varia-

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tions in the light stimulus contributes in a specific and measurable way to the physiologic response of the retinal receptors; thereby, they determine the characteristics of each light sensation. In binocular vision, the directional value of the light stimulus is of primary importance. What is meant by the directional value of the light stimulus?

If rays of light strike a retinal area in one eye of an individual, he not only perceives the light sensation, but he also is aware of the direction of its origin. Furthermore, if two retinal areas in the same eye are stimulated simultaneously, the observer will be aware of two distinct light sensations each seeming to come from a different direction in accordance with the relative anatomical location of the stimulated rods and cones. Stated in another way, every retinal area normally has an inherent and constant directional value in relation to every other retinal area in the same eye. Thus we are able to determine the relationship of objects in space to each other, independent of our own position, according to the differences in the direction of the origin of light striking our retinas. We can alter this relationship by placing a Maddox double prism before one eye. Then rays of light from a single object in space are divided and made to fall upon two retinal areas in the same eye. As these areas have different directional values, the object is seen in two directions, that is, doubled. Thus we have created monocular diplopia by what we term the mechanism of monocular diplopia of physical origin. This phenomenon illustrates the fact that for an object in space to appear as single it must be seen in only one direction. Cerebral integration of sensations of direction from the two eyes is the essence of normal binocular vision. How does it occur?

In relation to the directional values of light, approximately anatomically corresponding areas in the two retinas (such as the left half of each of the two foveas), have a common visual direction. Retinal areas having a common visual direction are designated as "corresponding areas." For example, if the left halves of the two foveas are stimulated simultaneously by mechanical or other means, the light sensations from the two eyes appear superimposed. This occurs even though the visual axes may be widely misaligned at the time of stimulation. This fact can be demonstrated with foveal afterimages. First one fovea and then the other is stimulated with an intense light source. The afterimages appear superimposed. Normally, each point of binocular single vision is imaged on anatomically corresponding areas in the two retinas. Pathways from corresponding retinal areas are closely related in the optic radiations and terminate in the same cortical area.

The normal correspondence between function and anatomical structure permits the major parts of the field of vision of the two eyes to overlap without conflict, providing that bifoveal fixation is present. For a given distance of bifoveal fixation, it is possible to localize a frontal plane (horopter) from which all rays of light will fall upon functionally corresponding areas in the two eyes. Objects lying upon the horopter appear to be single because they are seen in the same direction by the two eyes; however, an object may be slightly in front of or behind the horopter and still not appear doubled. This area of binocular single vision is called Panum's fusional space. Objects lying anywhere in this fusional space will be seen as single, but their directional values are slightly altered because they are visualized by retinal areas which are slightly disparate. Bitemporal disparity in correspondence creates the perception that an object is nearer than the point of fixation; binasal disparity creates the perception that the object is beyond the point of fixation. A type of three-dimensional vision, stereopsis, is thus made possible.

Normal directional correspondence is essential for normal fusion, but the two functions are not synonymous. There are other prerequisites to the fusional process. For example, corresponding areas, such as the two foveas, must receive the same pattern of stimulation. Earlier it was pointed out that a light stimulus, in addition to its directional variation, may vary also in intensity, wave length, duration, frequency and pattern. The physiologic response of the retina to variations in the intensity of formless white light is so characteristic that we can speak of a "light sense." Response of the normal retina to visible light of a specific wave length also is characteristic. The resulting light sensation has a hue which is specific and constant for that partciular wave length. This is designated as "color sense."

Under ordinary visual conditions, light stimulation of the retina occurs in a pattern that may vary in hue, intensity and contour. The focusing system of the eye creates patterns of the light on the retina which are real images of the object in space. Some of the receptor units of the retina are stimulated and others are not, according to the particular image pattern. The retina receptors function either alone or in small groups; thus, light sensations going to the brain must correspond to the image which is patterned on the retina. This is the anatomical and physiologic basis for form perception. It is sometimes called "contrast or contour sense."

Let us now consider how fusion might take place when the stimuli to normally corresponding retinal areas in the two eyes are the same, and also when they differ in these characteristics of intensity, hue or contour. All of these factors have been used in the investigation of the fusional process.

First, consider that the patterns of the stimuli are alike and that corresponding retinal areas are stimulated. If the stimulus to one eye is inadequate or insufficiently prolonged to produce a response, the simultaneous stimulation of corresponding retinal areas in the other eye by the same inadequate stimulus does not lead to a visual sensation. Likewise, if the two eyes are adequately stimulated simultaneously with formless light of the same intensity, hue and frequency, the visual sensation will be no different than if one eye were stimulated alone. Summation of monocular light sensations, therefore, does not occur in the fusional process. This has led many to believe that the stimulation of a retinal area always results in inhibition of corresponding retinal areas in the other eye so that first one, then the other, is dominant. According to this theory, binocular perception is a constantly changing mosaic of monocular perceptions.

Against this theory are some of the findings which occur if the pattern of the stimulation to the two eyes is altered slightly. Then the resultant binocular perception is a single one with some of the characteristics of each monocular sensation. If the stimulation to the two eyes differs grossly in wave length, frequency or intensity, one or the other is predominant at a particular moment in some part of the visual field. Sometimes a rhythmical alternation takes place which the observer cannot control. This is called retinal rivalry. It can be demonstrated by several techniques, all of which have clinical usefulness in testing for binocular perception in strabismic patients.

For example, if different intensities of formless white light are presented to the two eyes, the binocular perception acquires a luster due to changing and irregular intensities of light. This is called "binocular luster." At first, the darker, then the lighter intensity becomes dominant in different areas in the visual field. If different hues of formless light are presented to the two

eyes, color rivalry or fusion occurs. When fusion occurs, the color seen is similar to that resulting from the mixing of colored lights rather than that of pigments. In ophthalmic practice, retinal rivalry is noted in a number of conditions. For example, patients with a dense unilateral cataract are often aware of a darkening and brightening of the visual field if they stare in one direction at an intense light source. This commonly is called "interference," but it is merely an example of retinal rivalry due to different intensities of light stimulation to the two eyes.

What happens to binocular perception when corresponding retinal areas such as the two foveas, receive patterns of stimulation which differ in form and size? Earlier, it was mentioned that directional correspondence between the two retinas is not rigid so that fusion is possible when an object is not quite on the horopter. Panum's fusional space permits us to have fusion of objects which appear slightly different in size and shape to the two eyes. This occurs normally because the two eyes are separated by the nasal passages and therefore view every object in space from a slightly different direction.

If the images focused on the two retinas differ grossly in size and contour, fusion cannot occur and a third type of retinal rivalry may result. This can be demonstrated if the oblique lines slanting at different directions are presented to the two foveal regions. A varying pattern of first one, then the other, set of lines is seen. Retinal rivalry may also occur if there is a gross misalignment of the visual axes. Then different objects are imaged on the two foveas. The retinal rivalry that occurs under these circumstances is commonly called "confusion of images." After some days or weeks, the confusion of images becomes less noticeable as the individual begins to concentrate his attention on the sensation from one eye.

This predominance of sensation from one eye should not be confused with suppression, which functions in the relief of diplopia.

Under what circumstances do the images visualized by one eye become predominant to the exclusion of conflicting light sensations arising from a corresponding area in the other eye? Attention is an important factor. An unequal stimulus is another. If the stimulus to one eye is more intense, the stimulus to the other eye may not reach consciousness. This occurs when a monocular microscope is used with both eyes open; then it is easy to concentrate attention on the microscopic field because it is so much brighter than objects seen by the other eye outside of the microscope. This commonly is designated as "physiologic suppression" of the nonfixating eye, but it really is a predominance of the fixating eye favored by a brighter stimulus and attention.

Fusion is a perceptual process in which light sensations from the two eyes are integrated into a "fused" visual perception. What purpose does this fusion accomplish, that is, how does normal binocular vision differ from normal monocular vision or from the binocular vision which occurs in strabismus?

In everyday life, visual perception has three major purposes. First, to differentiate the features of objects in space as to size, color and contour, and to distinguish each object as an entity separate from other objects; second, to determine the relation of objects to each other independently of the observer's position; third, to orient the observer in relation to objects in space. Binocularity improves perception in all aspects.

Good form perception requires interpretation and identification of forms. Good form perception also requires visual attention, that is, the act of fixation. Remem-

ber, the fact that an image pattern is formed on the retina does not necessarily mean that it will be perceived. For example, a day-dreaming child has no visual awareness although his eyes are open and receiving visual stimuli. Clinically, we measure form perception by testing the visual acuity, and color perception by testing for color discrimination. Visual acuity, as tested by flat test charts, is not improved appreciably in binocular vision; however, form perception is enhanced in normal binocular vision because the two eyes visualize objects from slightly different angles. This gives objects an added three-dimensional appearance through the mechanism of retinal disparity.

The fact that each retinal area has a directional value in relation to every other retinal area in the same eye permits us to tell the relationship of objects to each other in space independently of our own position, but the greater three-dimensional quality of binocular perception improves our ability to orient objects in space relative to each other by giving them more form and contour. The enlarged field of vision in binocular perception also aids in this respect.

Vision plays a major role in the determination of our position in relation to objects in space around us, but other sensations, such as proprioception, also contribute to orientation. This brings up a discussion of "visual projection." Visual projection is not physical. Lines can be drawn to trace the direction of light from an object in space to the retina; however, we do not actually project light back from our retinas along fixed lines. Instead, we derive a mental conception of space and our position in it from physical stimulation of the retina by light. This conception can be quite misleading. Binocular perception improves the conception of our own position in space, particularly by improving depth perception.

There are many monocular clues that help the one-eyed patient judge distance so that neither his world nor the world of the patient with strabismus appears flat. On the other hand, there is no doubt that normal binocular perception adds more than stereopsis to depth perception. In distance gaze, all near objects are being imaged on noncorresponding retinal areas. We do not fuse these near objects and are not aware of seeing them double; however, these objects appear nearer to or farther from us in accordance with the retinal disparity that they create. This important factor is lacking in monocular vision.

It has been pointed out that fusion is the cerebral integration of light sensations from the two eyes into a unified visual perception. The nature of the light sensations arising from the two retinas is determined by certain physical characteristics of the light stimulus, such as the direction of its origin, duration, frequency, intensity and pattern. For light sensations to be integrated, similar light stimuli must be imaged on anatomically corresponding areas in the two retinas. These areas must have a common visual direction so that binocular single vision is possible. Fusion of the light sensations from the two eyes into a unified visual perception aids our visual function and is worth working for in the treatment of the strabismic patient.

With this knowledge of fusion as a perceptual process, rather than a fixed inherent faculty, it is possible to determine whether a strabismus patient has or does not have all of the sensory prerequisites for normal binocular single vision. How should such an examination be conducted?

The first essential is to determine if the patient has useful vision in each eye. Good visual acuity and a normal visual field are desirable, but an impaired visual acuity and moderately restricted fields of vision do not prevent fusion. A second phase of an examination might be to determine the refractive error in each eye. Here the ophthalmologist is concerned with obtaining maximal visual acuity for his patient and creating similar retinal images on corre-

sponding retinal areas. Gross anisometropia makes fusion impossible by creating dissimilar images.

Binocular perception is another prerequisite of fusion which should be investigated in strabismic patients. It is not an "all or none" process but may vary with the visual circumstances in the area of the retinal tests. In strabismic patients we are most concerned with the central retinal areas, and we usually confine our tests to them. Binocular perception can be tested by demonstrating the presence or absence of binocular luster, color rivalry or fusion, and pattern rivalry.

Finally, it is essential that directional correspondence be normal. This can be investigated by determining if anatomically corresponding areas, such as the two foveas, do or do not have a common visual direction.

It is in this area, the investigation of a patient's sensory potentialities for binocular vision, that haploscopic devices, such as the stereoscope and major amblyoscope, are most useful. Vectographs, prisms, and simple haploscopic devices also can be used. With these devices, circumstances can be created which are ideal for studying such phenomena as retinal rivalry and stereopsis.

ANOMALOUS RETINAL CORRESPONDENCE

Classification, Terminology, Results of Treatment Without Benefit of Intensive Orthoptics Using Instruments

ELSIE H. LAUGHLIN, O.T.
IOWA CITY, IOWA

THE incidence of anomalous retinal correspondence (ARC) in cases of strabismus is a subject which has given rise to considerable controversy in the past few years. Different authors arrive at vastly different conclusions regarding the results of treatment of ARC, as well as its incidence.

In his paper "Normal and Anomalous Correspondence," presented at the New Orleans symposium, Dr. Burian points out contrasting figures in the literature dealing with the incidence of ARC and comments as follows:

> Obviously these discrepancies are due to two related factors. One factor is the choice of the criteria by which a diagnosis of ARC is made, and the other is the type of test on which the diagnosis is based. Until such a time when it has been established by general consensus what we mean clinically speaking by ARC, the figures of different authors about its incidence are rather meaningless when compared with one another.

In reporting statistics from patients' records, the method by which the conclusions are arrived at must be stated. Even then there is a possibility of misunderstanding when ARC is discussed. For instance, there is a difference of opinion as to whether a "jump" of images on the major amblyoscope at an angle other than the objective angle constitutes ARC or whether this finding should be interpreted as suppression only.

In 1954 we saw 943 patients with squint. Each of these patients made from one to ten visits to the clinic during that year; the initial visit in some instances had been made prior to 1954. The resources at my disposal for this study have been the case histories of the first 264 of these patients, according to alphabetical listing. In cases in which ARC was found to be present, no attempt was made to "break" it with intensive work on the major amblyoscope. Therefore the treatment for ARC consisted largely of occlusion or occlusion combined with surgery.

The major amblyoscope was used in making evaluations of the cases. Grade I foveal and grade II macular targets were used. The age of the patient and the status of retinal correspondence at his first visit were noted, the latter to be compared with the status of correspondence at the most recent 1954 visit. For some patients the time interval from first to latest visit was several months; for others it was several years.

In Table I the number in each age group is stated. It is gratifying to see how many are in the preschool age groups, because the distribution would doubtless have been much different ten years ago. This table will be of further significance later in this discussion when it should be kept in mind that until the child is at least three years of age, it is rarely possible to obtain the subjective data necessary for evaluating retinal correspondence.

Table II indicates the classifications of the cases according to findings on the major amblyoscope and shows the distribution of patients in three different age groups, with results of testing at first and latest visits.

Read at the Fourteenth Annual Meeting of the American Association of Orthoptic Technicians, Oct. 9-11, 1955, Chicago.

TABLE I

AGE DISTRIBUTION OF 264 PATIENTS AT FIRST VISIT

AGE (IN YEARS) AT FIRST VISIT	—2	2	3	4	5	6	7	8	9	10	11	12	13 to 20	+20
NO. OF CASES	29	38	36	31	42	17	15	7	13	11	3	10	8	4

TABLE II

COMPARISON OF STATUS OF RETINAL CORRESPONDENCE AT FIRST AND LATEST VISITS OF PATIENTS IN THREE AGE GROUPS

CLASSIFICATION OF FINDINGS ON MAJOR AMBLYOSCOPE	2 YEAR		5 YEAR		12 YEAR	
	FIRST VISIT	LATEST VISIT	FIRST VISIT	LATEST VISIT	FIRST VISIT	LATEST VISIT
A. No subjective findings	38	8	9	3	2	2
B. NRC (fusion at objective angle)	?	15	12	23	2	4
C. Suppression, NRC ("jump" at objective angle)	?	8	2	3	1	2
D. Harmonious ARC (fusion at zero)	?	0	1	0	0	0
E. Suppression, harmonious ARC ("jump" at zero)	?	3	8	2	0	0
F. Unharmonious ARC (fusion between objective angle and zero)	?	0	3	1	0	0
G. Suppression, unharmonious ARC ("jump" between objective angle and zero)	?	1	7	3	5	0
No subsequent visit		3		7		2
Total cases in each age group	38	38	42	42	10	10

In the two-year age group early subjective findings were not possible. Obviously then, since the original status is not known, the most recent finding may or may not be due to a conversion of ARC to NRC (normal retinal correspondence). It should be understood however, that even in the absence of initial subjective findings, elastoplast occlusion is prescribed in every case in which glasses do not eliminate the shift for either distance or near when the cover test is used, or in which a deviation is present in the absence of refractive error. Surgery is done early when (1) NRC findings are verified; (2) occlusion has been unsuccessful after several visits spaced two or three months apart; or (3) there is evidence of equalized or considerably improved visual acuity in a very young child.

The largest group is composed of children five years of age who would soon be starting school. Even in this group there are a few patients in whom subjective findings could not be elicited at the first visit.

There are 10 cases in the age-twelve group. Patients with squint at this age usually have received no corrective treatment, and they are more or less conscious of their deformity. Two patients in this group are institutionalized; they are mentally retarded and unable to give subjective

TABLE III

RESULTS OF TREATMENT OF 264 CASES OF SQUINT
WITHOUT BENEFIT OF INTENSIVE ORTHOPTICS USING INSTRUMENTS

BEFORE TREATMENT		AFTER TREATMENT							
CLASSIFICATION*	NO. CASES	RECLASSIFICATION AT LATEST VISIT							
		A	B	C	D	E	F	G	NO SUBSEQUENT VISIT
A	119	40	36	17	0	7	1	3	15
B	54	0	46	1	0	0	0	0	7
C	10	0	7	1	0	0	0	1	1
D	8	0	7	0	0	0	0	1	0
E	23	0	12	3	0	4	0	1	3
F	12	0	5	3	1	0	1	2	0
G	38	1	22	3	1	1	0	6	4

*Classification designated by capital letters is the same as in Table II

reports. Occasionally a twelve-year-old patient is willing to try occlusion but more often surgery is done soon. However, ARC in patients with long-standing, large-angle deviations sometimes is known to be converted to NRC following surgery, and evidently this is true in two cases of this group (table IV).

I do not wish to give the impression that we give no orthoptic therapy. We reserve six half-hour training periods daily for patients who have arrived at a stage at which time can be spent to best advantage in developing amplitudes with and without the use of instruments. Such patients are usually given 5 or 6 treatments preliminary to appropriate home exercises.

Because of geographical and time factors involved, the patients in whom ARC is still present are dependent on occlusion and voluntary alternation exercises, rather than on intensive instrument work.

Table III shows the results of treatment of the patients of all age groups classified according to status of retinal correspondence rather than according to age group. A similar table could be assembled for each division in each age group. It would also add interest to this study if we had recorded the ages of the patients at the latest visits. This will be possible in the future with a more adequate cross-filing system.

Table IV groups the patients with ARC according to age (at first visit) in order to determine in which group prognosis is most favorable for conversion to NRC. The age-two-and-under groups can not be evaluated since there are no initial findings for comparison. Also the patients over 20 years of age are not included in the table.

By reference to table III, it is evident that at the time of the first visit there were 119 patients from whom no subjective findings could be elicited. Of the remaining 145 patients, 64 had NRC and 81 (56 per cent) had ARC.

At the time of the latest visit, excluding from the total 30 patients who made no subsequent visit and 41 from whom no subjective findings could be elicited, there remained 193 patients. Of these, 163 had NRC and 30 (16 per cent) had ARC.

It is generally conceded that there are more patients with ARC who suppress than who superimpose or fuse. A study of the classifications D, E, F, and G in table III confirms this assumption.

TABLE IV

CONVERSION OF ARC TO NRC IN DIFFERENT AGE GROUPS

AGE (IN YEARS) AT FIRST VISIT	ARC (ALL TYPES) AT FIRST VISIT	NRC AT LATEST VISIT
3	9	7
4	11	10
5	19	9
6	6	2
7	9	5
8	4	2
9	7	4
10	3	1
11	2	1
12	5	2
13-20	5	2
Totals	80	45

SUMMARY

A classification has been used for findings on the major amblyoscope which includes under ARC not only the presence of a definite subjective angle but also "jump" (suppression) at an angle other than the objective angle.

Within this classification are contained elements which account for some of the differences of opinion regarding (1) the incidence of ARC, and (2) the success with which it is treated.

The classification herewith presented seems justified because in a controlled situation such as we have on the major amblyoscope, all attempts by the patient to gain single binocular vision at other than the objective angle must be interpreted as anomalous retinal correspondence, at least for the specific time and testing situation.

Only by careful study of consistently recorded findings can we arrive at reliable conclusions regarding the comparative effectiveness of various diagnostic and therapeutic methods. Such study should also result in the adoption of more adequate terminology.

According to the above findings, treatment consisting largely of occlusion, or occlusion combined with surgery, gives surprisingly good therapeutic results—better than is generally expected.

USE OF MIOTICS IN ESOTROPIA

PHILIP KNAPP, M.D.
NANCY M. CAPOBIANCO, O.T.
NEW YORK, NEW YORK

JAVAL[6] in 1896 was the first to use miotics in the treatment of esotropia. Independently, Abraham[1] in 1949 published a preliminary report on 44 cases of esotropia treated with the miotics: pilocarpine, eserine and di-isopropyl fluorophosphate (DFP). In August 1952, he added 88 cases,[2] making a total of 132 cases: 109 periodic, 23 constant. He reported that treatment with miotics was particularly successful in cases with good and equal visual acuity and with an equal hypermetropic refractive error in each eye. As one would expect, such treatment was more effective in periodic esotropia as compared to constant esotropia. Up until August 1953, Abraham had encountered only two sensitivity reactions in 300 cases treated with miotics.[3] At that time he become aware that such miotic therapy tended to produce cysts of the pigment seam of the iris. In March 1954 he published an article on these cysts of the pigment seam of the iris with some beautiful illustrations in color.[4] In this series of 66 cases, 42 had developed these cysts of the pigment epithelium at the pupillary border. The age of the patients ranged from 2.5 to 23 years, averaging from 6 to 9 years. Cysts appeared in from one to forty weeks, with the average interval ten weeks. He found good miosis associated with the development of the cysts, whereas with active pupils, cysts did not appear. On stopping the miotic, the cysts shriveled up in from 2 to 42 weeks, all but four in 15 weeks. In these cases he had been using DFP once or twice a day.

From the Department of Ophthalmology, Columbia University College of Physicians and Surgeons, and the Institute of Ophthalmology, Presbyterian Hospital.

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The theoretic basis for the use of miotics in esotropia is that accommodation produced peripherally by direct stimulation of the ciliary muscle will reduce the need for central accommodation with its associated convergence. A miotic should prove useful in eliciting the accommodative factor in any case of esotropia and in correcting accommodative esotropias, particularly those so-called atypical accommodative esotropias. These are straight for distance with glasses but break into an esotropia for near focus, due to an abnormal accommodation-convergence ratio, or to hypo-accomodation requiring excessive accommodative effort.

Di-isopropyl fluorophosphate (DFP, floropryl), has superseded pilocarpine or eserine. It requires less frequent instillation and less constant supervision, since DFP forms an irreversible combination with local cholinesterase, thus necessitating either its replacement from elsewhere in the body or new local synthesis. Although solutions of varying strengths from 0.005 to 0.05 per cent were tried, there appeared to be no greater effect from stronger concentrations than from the weaker ones. For shelf stability, we now use 0.025 per cent floropryl (Merck), or have the local pharmacist dilute the standard 0.1 per cent solution of floropryl with peanut oil, U.S.P. There is no apparent advantage in using sesame oil or anhydrous mineral oil with 2 per cent polyethylene ointment as the vehicle instead of peanut oil.

When we began using DFP in the treatment of esotropia we limited its use to the theoretically favorable cases. Encouraged by initial success, we started using DFP in all sorts of esotropia. This optician's

nightmare came to an end in September 1953 following Abraham's article about the production of iris cysts.[4] We then began examining all of our cases for these cysts. We found that practically every case which had been given miotics at nightly intervals for over two months had developed cysts. We immediately stopped using the miotic until we noticed that those cases which received an instillation every other night, or less frequently, had not developed iris cysts. Just as Abraham[4] reported, the iris cyst shrivels up like a grape turning into a raisin after the use of the miotic is stopped. We believe that the production of the cysts is due to immobilization of the iris against the surface of the lens rather than upon the development of miosis. We found that iris cysts were just as common in pupils 3 to 4 mm. in diameter as in miotic pupils. The crux of the matter was in the reactivity of the pupil. With active pupils, cysts did not develop; with sluggish pupils they did. This suggests a hypostatic mechanism.

Our efforts to produce iris cysts experimentally in the rabbit and guinea pig failed. Even tabun, reported to be many times more powerful than DFP,[5] does not produce a constant miosis for twenty-four hours in these animals. However, thanks to Dr. Leonard Christensen of the Eye Pathology Department of the University of Oregon Medical School in Portland, we have a slide showing the eye of a 12-year-old boy who had been on DFP therapy for glaucoma. The development of iris cysts led to the mistaken diagnosis of malignant melanoma, for which the eye was enucleated. Unfortunately the cyst collapsed on sectioning, but one can definitely see the changes in the epithelium of the pigment seam of the iris.

With this as a background, we have gradually evolved our present regimen for using DFP: In those cases in which we wish to elicit the accommodative component, DFP is prescribed, one drop in each eye at bedtime for two weeks. Bedtime is chosen over a morning hour to minimize possible brow ache and visual blurring from ciliary spasm, and to avoid the annoyance of looking through an oily film. The two-week interval is chosen to minimize the chances of producing iris cysts, and yet to give as much time as possible to evaluate the effect of the drug. The mother of the patient is warned to keep the bottle tightly stoppered, and to avoid washing the dropper or touching it to the conjunctival sac lest the DFP become hydrolysed and ineffectual. At the end of the two weeks the patient is re-examined. If there has been little or no reduction in the amount of the deviation, the accommodative component is estimated as negligible. If there has been significant reduction or complete elimination of the deviation, the miotic therapy is continued for two months at a frequency of every other night. If this regimen fails to eliminate the deviation, miotic therapy is stopped. In cases in which the deviation had been eliminated by nightly instillation of DFP but not by instillations every other night, glasses are prescribed. In cases in which the deviation had already been eliminated by glasses, DFP therapy is started at a frequency of every other night. On this regimen no case has developed iris nodules of significant proportions and only a few cases have developed even small nodules.

Our use of DFP started in January 1953 and the findings are as of September 1955, a period of thirty-two months. In all, we have treated 277 cases. The average age of the patient at the time miotic therapy was started is 5.75 years, with a range of age from 4 months to 27 years. The refractive errors ranged from plano to +7.00.

The reasons for trying miotic therapy in the 277 cases are given in table I. The apparent discrepancy in numbers is due to the fact that some cases fall into two categories: for example, after amblyopia had been treated, the same case was then placed on DFP in each eye to elicit the accommodative component of the esotropia.

TABLE I

REASONS FOR STARTING DFP

Instead of trial of glasses	102
Instead of glasses	116
Amblyopia	41
Anisometropia	1
DFP and glasses	5
Instead of glasses for the summer	6
For spasmodic esotropia for near	13
Total	284

TABLE II

COMPARISON OF VISUAL ACUITY WITH GLASSES AND WITH DFP

Same	85
Better with DFP	7
Worse with DFP	7
Too young for testing or failed to return	17

The 102 cases in which DFP was prescribed rather than glasses were cases with refractive errors within the normal range of hypermetropia for their age group in which we wished to elicit the accommodative element in the esotropia before deciding on further therapy.

There were 116 cases in which DFP was prescribed instead of glasses. Table II shows the comparison of DFP with III shows the comparison of DFP with glasses with regard to visual acuity. In only 7 cases was there a significant reduction in visual acuity of two lines or more. Of these 7 cases in which the visual acuity was worse when DFP was used than with glasses, 4 showed significant astigmatic errors of +1.50 and over; one showed 6 diopters of hypermetropia, and the other 2 showed refractive errors of +2.75 and +2.00 respectively. The cause of the reduced visual acuity in the first 5 cases is apparent. In the last 2 cases it probably represents an induced myopia.

TABLE III

COMPARISON OF DEVIATION WITH GLASSES AND WITH DFP

Same	88
Failed to return	11
Better with DFP	11
Worse with DFP	6

Table III shows the comparable effectiveness of DFP and glasses in regard to control of the deviation. The criterion for improvement was a shift from constant tropia either to intermittent tropia or to phoria for distance and near. Slight shifts in the measured amounts of deviation were discounted as being within the margin of error of the examination. In general, the measurements for distance were slightly worse with the miotic, whereas the measurements for near were better when the miotic was used. Cases that were relatively orthophoric for distance but esotropic for near with glasses sometimes changed, showing a small esotropia for distance, with the esotropia evident on near measurement becoming intermittent or changing to a phoria. The mechanism of this change in the distance measurement is unknown. Perhaps the peripherally induced accommodation inhibits negative accommodation with its associated divergence, simulating a divergence paresis and producing an esotropia for distance. Such shifts were considered as neutralizing each other and are not counted as better or worse in our tabulation. Of the 6 patients who were worse on DFP, one had a significant astigmatic error. In the other 5 cases the errors ranged from +3.00 to +5.00. In two of these the deviation had been controlled by instilling DFP every night, but on a dosage frequency of every other night esotropia developed. In the remaining 3 cases the reason for failure is unknown, but unfortunately no note of the pupillary size was made and perhaps the drug had become hydrolyzed.

Of the 13 cases which showed relative orthophoria for distance with a marked esotropia for near fixation in spite of full strength distance correction, 7 cases were changed to small esophorias for near by the instillation of DFP. Two of these cases had had previous bimedial recession of the interni. In 5 cases, DFP failed to eliminate the in-shoot on focusing. One patient failed to return. In one successful case the patient had been orthophoric with bifocals.

In the treatment of amblyopia, if the child with hypermetropia refuses to tolerate complete occlusion or if it is practically impossible to keep a patch on during hot weather, DFP is instilled at bedtime every other night in the amblyopic eye and atropine is instilled daily in the fixating eye. This method appears to be more satisfactory than use of atropine in the fixating eye alone, as it stimulates accommodation to decrease the hypermetropia and thus increases the clarity of the image in the amblyopic eye. In cases with significant hypermetropia, atropine in the fixating eye sufficiently blurs its image, particularly for near, so that the child starts using the previously amblyopic eye. In the case of eccentric fixation, the blurred but correct visual direction of the previously fixating eye appears to help the child start fixating centrally with the amblyopic eye.

In the successfully treated cases, the child first switches fixation for near to the amblyopic eye while continuing to fixate for distance with the nonamblyopic eye. Next the fixation shifts for distance also. Care must be taken to stop the instillations of atropine at this time or a difficult amblyopia may develop in the previously fixating eye. If the child is old enough for the visual acuity to be checked, putting the refractive correction before the atropinized eye keeps a check on the development of amblyopia in this eye.

In 41 cases treated in this fashion, 15 have successfully been switched completely or made to alternate fixation. Seven cases are still under treatment. This does not appear to be an astounding percentage of success save that in 10 of these occlusion had failed completely. Of the 19 failures, 3 had had to have the miotic stopped because of (1) headaches, (2) tantrums, or (3) iris nodules after four weeks. Six of the remaining 16 failures were cases of grossly eccentric fixation. These cases remain a therapeutic dilemma. Six of these patients have had orthoptic training with hand and eye exercises; training has been successful in two of them, although they showed definite eccentric fixation before treatment.

TABLE IV

RESULTS OF TREATMENT WITH DFP

A.	Still on glasses and DFP	2
B.	Developed exotropia	2
C.	Back on essential glasses for school	5
D.	Reaction to DFP	20
E.	Allergy to DFP or peanut oil	3
F.	Pigment cysts of pupillary seam	16
G.	Failed to return	11
H.	Preferred glasses	2
I.	After treatment for amblyopia	38
J.	Still esotropia	124
K.	Still on DFP	44
L.	"Cured"	10
	Total	277

Table IV shows the results of miotic therapy.

A. Three of the five patients placed on a regimen of DFP and wearing full strength glasses showed no improvement, and the miotic was discontinued. One patient has not returned for evaluation. The fifth patient has been wearing $+4.50 \bigcirc +1.00$ cax 90° O.U. and has been on a regimen of DFP twice a week for the past 20 months; his last measurement indicated orthophoria for distance and esophoria, 6 prism diopters, for near.

B. Two cases became exotropic, so use of the miotic was stopped.

C. Of the six patients placed on DFP for the summer vacation, one developed a reaction to the drops and the other five resumed their glasses when school began in the fall. One of these has done this for three summers; and two, for two summers.

D. Twenty patients developed a reaction to the drops, which consisted of brow ache, or redness and pain. In all cases the drops were discontinued.

E. Two patients developed typical follicular conjunctivitis which was attributed to an allergy. One patient developed a cough on the day following the instillation of the miotic. This cough ceased when the miotic was stopped, so it, too, was attributed to an allergy.

F. Although many patients developed mild cystic changes in the pigment seam of the iris, 16 were actually taken off miotic therapy due to this complication. Some of these had responded well to the miotic, and the parents were most upset because the child had to return to wearing glasses.

G. The 11 cases in which the patient failed to return require no comment.

H. In only 2 cases were glasses preferred to miotic therapy. Not all the children like the drops, but when offered the choice between glasses and drops, this has been their decision.

I. In 38 cases miotic therapy was stopped after this phase of the treatment for amblyopia had been discontinued.

J. In 124 cases the miotic was stopped because a significant esotropia was still present.

K. Forty-four patients are still on a regimen of DFP. Forty of these will be considered together, and the other four separately. Of the first group, the refractive errors ranged from +1.25 up to +5.50 with an average of +3.3. In 32 of these cases the refractive error was between +2.00 and +4.00. Only 4 had significant cylindrical refractive errors of between +1.50 and +2.00. There were 2 instances of anisometropia of 1 diopter and 1.25 diopters, respectively. These patients have had miotic therapy for an average of 12.3 months, with a range from 2 to 27 months. Nine of these have had therapy for two years or more. The frequency of instillation is now every second night in 20 cases, twice a week in 13, and weekly in 7. Prism cover-test measurements taken in the afternoon of the night when the next drop was due revealed 7 cases to be cosmetically straight with a small esotropia, 16 cases to be small intermittent esotropias, and 17 presented orthophoria or an esophoria of less than 10 prism diopters. In all cases these measurements revealed fusion with amplitudes on the troposcope with varying degrees of suppression. It was difficult to give these patients orthoptic training while they were on miotic therapy, and it is our opinion that those patients who had had antisuppression and fusion training before being placed on miotics showed better binocular cooperation sensorially than those patients who had not had this training. In several cases miotic therapy was interrupted for such training and then reinstituted after the sensorial status had been improved.

Of the four patients singled out for individual comment, one was 8 years of age with +4.50 O.D. and +2.50 O.S. With glasses, which he detested, he had an esophoria of 3 prism diopters for distance and near. On miotic therapy in the more ametropic right eye only, at twice-a-week intervals, he has maintained this status without glasses for fourteen months. The second case was that of an 8-year-old girl with refractive errors of +4.00 ⌒ +2.00 cylinders in each eye. Her esotropia had existed from infancy, and she had been treated with glasses since the age of 4. Two trial series of orthoptic training had been given, and she had used the television-polaroid trainer for two years. In spite of this she showed an esotropia

of up to 40 prism diopters for near when she was tired or when she accommodated. A miotic was tried, but she balked, stating it blurred her vision. She had a cautious bimedial recession which reduced but did not eliminate her deviation for near. Her glasses were reduced to +1.00 spheres with full cylinders, and she was started on a regimen of DFP and orthoptic training. She now has orthophoria for distance and an esophoria for near of 7 prism diopters. She wears her glasses only for visual tasks.

The third and fourth cases were those of young ladies, aged 25 and 27 respectively, who each showed refractive errors of +6.00 in each eye and an amblyopia of 20/70 in the habitually deviating eye. With full correction, each displayed a cosmetically satisfactory residual esotropia, but both without glasses had a large esotropia. Each felt that glasses were interfering with her social life. In the first case, the glasses were reduced to +3.00 spheres, which produced a deviation of 25 ST and 30 ST′ with retention of 20/20 visual acuity in the fixing eye. Miotic therapy was then instituted, and with a frequency of instillation of twice a week, the patient's eyes are straight and she has used her glasses only for close work for the past five months. The second patient had a single recession of her left medial rectus muscle, which temporarily allowed her to look straight with only +3.00 spheres. However, she was bothered with postoperative diplopia, and one month postoperatively she reconverged her eyes so that the visual line of the deviated eye fell on the optic nerve head. She was placed on a regimen of DFP every second night, which reduced her deviation to relative orthophoria. She has maintained this regimen for seven months, and uses her +3.00 glasses only for close work. She is a school librarian.

L. The final group for discussion are the ten "cures." Average age at institution of miotic therapy was 6 years, with a range of 4 to 9 years. Average refractive error was +2.8, with a range from plano to +5.00. It is interesting to note that the visual acuity of the case with plano refractive error was 20/30 with the E chart, each eye. Average length of treatment was fourteen months, with a range from four to twenty-seven months. In all cases the esophoria measured less than 10 diopters. On the troposcope all patients showed steady fusion with good amplitudes and minimal suppression. The average follow-up after stopping treatment was eleven months, with a range of from one month to twenty-four months. Needless to say, much longer follow-up is necessary in order that these cases may be classified as really cured.

In conclusion, it is our feeling that miotic therapy has a definite place in the treatment of esotropia. It is not a "cure-all," but it is a useful adjunct to other recognized measures. If used judiciously, it is perfectly safe.

SUMMARY

1. DFP is as good or better than glasses in correcting esotropia ranging from +2.00 to +4.50 unless there is significant astigmatism of +1.50 or more.

2. It is particularly useful in eliciting the accommodative factor preoperatively in very young patients, and in patients with normal hypermetropic refractive errors when one wishes to avoid the expense of glasses but wants to know the accommodative factor.

3. It is superior to single-vision lenses in treatment of patients with an abnormal accommodation-convergence reflex but is still not the entire answer to spasmodic inshoot on accommodation.

4. It is a useful adjunct to the therapy of amblyopia.

5. It may be useful in cases of anisometropia or when used in addition to glasses of reduced strength, but we have treated

so few cases of these types that we cannot be sure.

6. About 8 per cent of patients are unable to tolerate DFP, but actual allergy occurs in only 1 per cent.

7. The danger of the production of iris cysts is minimal if daily instillation is not continued longer than two weeks. In those cases in which the deviation was eliminated on daily instillation of the miotic or by glasses, DFP is administered every other night, or less frequently, without producing iris cysts of significant size.

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TWO POINTS OF VIEW ON THE ORTHOPTIC MANAGEMENT OF STRABISMUS

ANN T. EUSTIS, O.T.
MARY FERGUSON
CHICAGO, ILLINOIS

MISS EUSTIS: This paper is the outcome of spontaneous discussions that have arisen at the Chicago Orthoptic Institute over some of the cases during the last eight months. One of the joys of working with another technician is the opportunity to talk things over as they arise. Although our aims and our objectives are the same, we have found that there is often a difference in the way we look at problems and that our points of view sometimes conflict. With time, we have come to appreciate that there is room for these diverse opinions and that it is stimulating to work under these conditions. The differences that we find do not necessarily arise, as one might think, from our diverse experience and basic training, although there is no doubt that these factors play a part. We expected to find some variance in technique, but this has proved to be relatively unimportant. We think that we are not alone in having these conflicting views. We have been trying to evaluate them, and we still have many unanswered questions.

One of our first differences arose over the treatment of abnormal retinal correspondence. The challenge came over a particular case which I instance to clarify the position. In this case there was no doubt that we agreed on the diagnosis of abnormal retinal correspondence, but we did not agree on the management.

The case history was as follows:

David, age 11, came to us for the first time last spring with a history of alternating esotropia since the age of two years, or possibly earlier. His vision was equal in both eyes, but he showed a preference for the left eye. His deviation appeared to be essentially mechanical in nature, although it was slightly less with his small hyperopic correction. Our troposcope findings definitely indicated attempts to fuse at a subjective angle of orthophoria to 10 diopters of esotropia, while the objective angle was 40 diopters of esotropia with a resulting crossed diplopia at that angle.

My procedure in such a case is alternate occlusion, with more occlusion on the dominant eye, and a series of six sessions with the orthoptist to see if normal fusion can be stimulated at the objective angle. If it appears that the correspondence is changing from abnormal to normal, another series will be recommended to the doctor; if there is no change the patient will be returned to the doctor for surgery. This particular patient was under Miss Ferguson's care and she will state her views on the procedure in this case.

MISS FERGUSON: This boy appeared to me to have a typical case of abnormal retinal correspondence with early onset of strabismus. He had equal vision in both eyes and a low refractive error. Although I followed the procedure outlined above and gave David a series of six treatments in an effort to establish normal retinal correspondence, my own choice would have been to do nothing orthoptically beyond the preliminary investigation. Once sure of my findings, I would have referred him back to the doctor for surgery. As it turned out, he did not respond to treatment and was referred back after six visits. In May he had a recession of the right medial rectus and a resection of the right lateral rectus. The result to date is excellent from a cosmetic standpoint. Since the surgery I have

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seen David for observation only, and I am pleased with what I find. The measurements with the prism cover test are now a slight apparent esophoric movement at 20 feet and an esotropia of 6 prism diopters, at the most, at 13 inches. On the troposcope the objective angle is zero, varying to minus 10 prism diopters, with a subjective angle at minus 20 prism diopters. David no longer wears his glasses because his eyes tended to diverge with them. The objective and subjective angles seem to be very close at times now, and this may indicate that suppression is altering while the visual axes remain straight. David volunteers that he has diplopia often in his casual seeing, but that it does not bother him. It is crossed from the abnormal retinal correspondence. (It is interesting to note here that David has always had a normal afterimage.) I feel that he will suppress this diplopia, and spontaneous fusion may well occur if the visual axes remain as they are. In my opinion, David is adjusting as well as one can hope, and I see no reason why he will not continue to do so. I am sure that there is no need for more than a watchful eye, and I am certainly more optimistic about this case now than I was before the surgery. However, as before, Miss Eustis and I are not in agreement upon this postoperative management.

Miss Eustis: When David returned to us after surgery, his objective angle on the troposcope was zero, but no fusion was present. He had diplopia. I feel that this postsurgical period is a very important time for orthoptics and that the patient should be seen two or three times weekly for stimulation at the objective angle. If normal fusion is elicited, a patient is seen for twelve visits and then given a rest. If, on the other hand, normal fusion is not elicited by the sixth visit, I discontinue active orthoptic training and recheck the patient in one month. I feel very strongly that orthopic training should not be given over an extended period. We must not underestimate the value of rest periods and the importance of the time factor. We cannot always expect to change in a few months what has been going on for years. In the case of David, it was Miss Ferguson who talked with the doctor, and so, with his consent, no treatment has been given.

Soon after we began working together it became apparent that there were differences in terminology. I found that I placed my patients in either of two groups as far as retinal correspondence is concerned—those who fuse at their objective angle, normal correspondence; and those whose subjective angle with fusion or crossing point is at an angle less than that determined objectively, abnormal correspondence. My reason for lack of discrimination in the second group has been that my treatment has been the same for all those who do not fuse at their objective angle. Our discussions in the office have led me to wonder if a further evaluation and division of this large group of nonfusors might not help us to make a more accurate diagnosis and prognosis. Miss Ferguson uses the term "lack of normal retinal correspondence" to cover the large group that falls between normal and abnormal retinal correspondence. The term is by no means new, but I feel that it is worthy of our further consideration and possible inclusion in our working vocabulary.

Miss Ferguson: For treatment purposes I am perhaps more specific in my use of the term abnormal retinal correspondence. I use it to mean that there is an actual superimposition of images, as seen on the troposcope, at an angle less than the objective angle. I do not use the term to cover the much larger group of cases in which there may be no more than a crossing, or jumping over, of images at an angle less than the objective angle, with diplopia at the objective angle. I use the term "lack of normal retinal correspondence," or, more loosely, "lack of binocular vision." The number of actual abnormal retinal correspondence cases that I can claim to

have seen is limited, and I am still of the opinion, based on experience with these comparatively few cases over several years, that the prognosis for obtaining a true binocular response in clearly defined cases of abnormal retinal correspondence is poor before the visual axes are rendered parallel. I also feel that if normal correspondence is going to occur, it will occur spontaneously when the visual axes have been aligned over a period of time. The larger number of cases that have lack of normal retinal correspondence, I treat as potential binocular cases and give them orthoptic training.

MISS EUSTIS: Having discussed the relationship of various types of retinal correspondence to prognosis, we soon began to consider occlusion for amblyopia in this light. My experience is very limited because the patients referred to me generally have 20/70 vision or better. In general, I occlude the fixing eye in every case in which central fixation is present in the deviating eye.

Our general policy has been to recommend surgery when the vision in the two eyes is equal, or as near to equal as possible, without waiting to see whether the vision will maintain the new level. To date, I feel that I have not given enough consideration to the age at onset of the strabismus in regard to prognosis for binocular vision after occlusion, and I feel that in some cases I have occluded longer than was warranted by the binocular response of the patient. However, since many of you are seeing patients before any occlusion, I think that you will be interested in Miss Ferguson's views, and questions, which are the outcome of work at a large county hospital.

MISS FERGUSON: Miss Eustis and I are agreed that we should occlude for amblyopia in strabismus unless there is some overriding factor which makes treatment inadvisable. I occlude in some cases, however, with a question as to the outcome. When the strabismus dates from infancy, and the origin is obscure, I use occlusion, wondering to myself whether we are dealing here with one of our later problem cases. Will this patient obtain greatly improved vision in the amblyopic eye? If he does, will he fuse with sufficient amplitude for his casual seeing? More important, will he continue to fuse when he leaves us? To many cases we give much time and thought, and then are left to wonder what the final outcome will be. We occlude, we continue with binocular training, and eventually we obtain fusion on the instruments, but only after much toil and time, and then we come to a full stop. Will the patient really fuse in his casual seeing? Although we follow the same procedure and feel that we must give each patient the opportunity of help towards a single binocular vision result, we differ in our attitude towards some. I think that Miss Eustis regards most of her cases for training as potential binocular cases and follows them through with this in mind. I begin to wonder about some at a much earlier stage. I wonder whether in these cases which take so much time and effort with often so little reward — the weak fusion cases, we can call them here—the patient might not have been saved much trouble by a cosmetic operation at an earlier stage, followed by orthoptic checks to observe any possible indications that a binocular result might be obtained by training. I feel that we could be even more selective than we are in taking on patients for occlusion and training and thus avoid some of our doubtful results. I have asked elsewhere whether we should occlude patients who are not binocular at any time and never have had the opportunity to be binocular. If the vision responds to occlusion, but cannot be maintained without occlusion, and if no binocular vision occurs, is prolonged occlusion justified, and for how long?

Miss Eustis mentioned that surgery may follow soon after the occlusion for amblyopic vision in some of her cases, and here I would like to say that when I occlude

for amblyopia in a case of strabismus, I like to know that the vision has improved as much as possible, that alternation is present when possible, and that this state has been maintained without the aid of occlusion for a short time before surgical measures are taken. I find that this helps to ensure that vision is stabilized and that occlusion for amblyopic vision may not be needed while binocular training and surgery are being carried out. I am not suggesting here that no occlusion may be necessary during binocular training; I appreciate that occlusion in some cases is required to help prevent suppression.

We have not brought before you more than (1) a difference in terminology and diagnosis and (2) a difference in approach to some cases with a view to prognosis, but we have found that these were the two factors which accounted for the many instances when we tended to conflict over management of cases.

MISS EUSTIS: Although our techniques may vary slightly, we have found that we are in complete agreement on the handling of phorias, pure accommodative esotropias and intermittent exotropias. We both have reservations regarding the generally optimistic view that cases of exotropia of the divergence-excess type respond to exercises alone in most cases. Here, too, I feel that we should be more honest in our appraisal and should consider preoperative orthoptic training as enhancing the postoperative prognosis rather than regard surgery as a defeat for orthoptic training in such cases.

It is our hope to focus attention and discussion on the desirability of an early determination of prognosis and a more precise selection of our cases. Although it is essential that we help all those who can benefit from orthoptic training, it is also important that we do not overestimate our capabilities. We owe this honest evaluation not only to our patients and doctors but to ourselves as well.

OCCUPATIONAL ORTHOPTICS

GLENDON G. SMITH, O.T.
HEDWIG S. KUHN, M.D.
HAMMOND, INDIANA

CALUMET, Indiana, and its environs, has a high concentration of industry in which exists every known type of job operation—many requiring the most complicated combinations of visual skills both for distance and for near. Hence the opportunity to study near-vision problems is ideal, and the need very real. Inspection of every type, small-parts assembling, tabulating, looping in hosiery plant, blueprinting, drafting and many other skills requiring critical near vision are among the occupational requirements of the industrial worker. This unique opportunity and responsibility focused our attention on the need for special study of practical methods of assisting such individuals, especially those in need of training for near work.

The theory which we have always followed is that if a person has an exophoria, a convergence insufficiency or a divergence excess which produces symptoms, that person needs treatment. On the other hand, a person whose ocular measurements indicate the presence of a degree of exophoria without the production of symptoms does not require treatment. The tolerances of people vary widely. It is important to emphasize that our choice of men and women to whom so-called "occupational orthoptics" is offered is entirely limited to individuals having trouble with near work. Perhaps because of this demonstrable need, the patients' cooperation has been excellent. Furthermore, our results were correspondingly better in adults than in cases of teen-agers, as the adult is usually the breadwinner.

Each patient who is scheduled for orthoptic training is first of all given a refraction, often under a cycloplegic, in order to determine whether the patient's present glasses have a plus component which he does not need or which he needs but does not tolerate well. Every patient has laboratory examinations, with special emphasis on blood pressure, red blood cell count and hemoglobin, as we have found over the many years that an individual with a low hemoglobin and low red blood cell count, or with a toxic focus of infection, does not respond well to orthoptic training. We need to know of any abnormalities so that we can administer to the patient all necessary medication and care as we go along.

Among the individuals whom we trained were many who were exceedingly important and busy people. These included university professors, general superintendents of large mills, and key people in business and industry who were under great stress. For these people we had to make concessions as to the time of day at which training was scheduled and as to promptness at our clinic because some of them had to come a considerable distance. We urged a minimum of two training periods a week. Relief of severe headaches in doing "must" tasks, elimination of total inability to work, and removal of frustration were among the results which contributed to everyone's satisfaction. The method and results of training in a pro-

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gram of this type, which we label "occupational orthoptics," are now given in considerable detail.

Over a period of 24 months, a group of 126 patients who manifested the subjective and objective findings of convergence deficiency were given orthoptic treatment at our clinic. Each patient was carefully examined medically and ophthalmologically to determine errors of refraction and physical and psychological factors which might in any way contribute to his symptoms.

Method of Examination and (Orthoptic) Diagnosis

After the history was taken and the medical examinations were completed, the following procedures were done:

1. Determination of the approximate amount and type of deviation with the cover test, at 20 feet and 13½ inches
2. An objective measurement, recorded in centimeters, of near point of convergence (NPC) and subjective awareness of diplopia at NPC
3. A study of versions
4. Actual prism measurements by means of a troposcope, (a) for distance, (b) for near, by addition of −3.00 spheres at 18△ base out (B.O.)

Prism and cover test measurements were done only when there appeared to be a significant discrepancy between the findings on the troposcope and those by the cover test.

It must be noted here that patients tend to show slightly more esophoria and slightly less exophoria on the major amblyoscope than with the prism and cover test because of the awareness of nearness, a fact which is well known to the experienced technician and is carefully considered here.

5. A careful determination of (a) fusional amplitudes; (b) stability of fusion; (c) suppression; and (d) the patient's ability to converge without discomfort.

Of the above steps in examination and diagnosis, we consider the fifth to be the most important and of the greatest significance in indicating or contraindicating orthoptic treatment. The four factors enumerated might well be the criteria for the diagnosis. As other writers have pointed out, convergence insufficiency may exist unassociated with exophoria, esophoria, or hyperphoria; also it may exist in association with any one of these.

If inadequacies of each or any of these functions exist associated with symptoms of asthenopia, then orthoptic treatment may well be indicated.

The method here described has proved convenient, efficient and satisfactory in determining and diagnosing cases of convergence deficiency.

I should like to point out here that my choice of the major amblyoscope (troposcope) is based on my own experience. The naive adult subject is inclined to be rather tense and inhibited on first examination, and he will more readily relax when placed before a major amblyoscope in a slightly darkened room. Then, if desired, on any subsequent visit prism and cover test measurements may be obtained with greater ease.

Much has been written pertaining to methods and techniques in treatment of convergence insufficiency; most of the procedures are effective and satisfactory. Nearly every orthoptist has his or her own pet technique which may be more or less elaborate.

Method of Treatment

The following methods used in our office are not entirely original, as will be readily recognized, but we use them for the sake of effectiveness, speed and convenience:

1. The patient is instructed in physiologic diplopia (using pencils or any other suitable object) as a convergence exercise and as an antisuppression exercise. This instruction is given on the very first visit, and the patient is requested to practice the exercise for about 10 minutes, two times each day until his next office visit.

2. Then fusion training is commenced on the major amblyoscope, beginning with developing convergence control; convergence-divergence control with sustained fusion follows. This is continued until the patient has acquired stable fusional amplitudes on the troposcope, and can converge to 50△ or 60△ B.O.

3. The patient is then started on training with loose prisms, base out, first at near. When he can easily overcome 50△ B.O. at near, he is taught to accomplish this task at distance (10 feet) until he can smoothly and without discomfort, overcome 50-60△ B.O. at distance and at near.

4. Home exercises with a loose prism set are done for 6 to 9 weeks or longer.

5. Ortho-fusers are frequently recommended for home use as an adjunct to orthoptic training, and have been found to be helpful particularly to those individuals employed at desk jobs or in executive positions. It is suggested that "push-ups" with physiologic diplopia should be practiced occasionally as well.

Frequently patients are seen who have visited other oculists, and have had their condition explained to them along with the instructions to carry out the well-known "pin-to-nose" exercise. Many will complain that though they practiced this exercise religiously they felt little or no improvement. It would seem a far wiser procedure first to teach physiologic diplopia as an antisuppression exercise as well as a convergence exercise, so that the patient can easily be aware of errors such as suppression.

Teaching of physiologic diplopia can be accomplished in most cases in about 10 or 15 minutes. This is time well spent, and the patient will frequently report considerable alleviation of symptoms as well as objective improvement in convergence on his following visit.

However, the purpose of this paper is not to point out new techniques of treating convergence insufficiency but to attempt to bring to light the fact that in this entity the individual's problems bear a significant relationship to his occupational tasks.

OCCUPATIONAL ORTHOPTICS

For the purpose of this study the patients are divided according to sex and occupations.

AGE DISTRIBUTION OF 68 MALE PATIENTS

AGE IN YEARS	NUMBER OF PATIENTS
20	9
21 to 30	24
31 to 40	19
41 to 50	11
51 to 60	5

OCCUPATIONAL DISTRIBUTION OF 68 MALE PATIENTS

Clerks and accountants	17
Engineers (chemical)	12
Students	13
Precision machine operators	4
Industrial laboratory technicians	3
University professors	3
Business executives	3
Opticians	2
Jewelers	2
Printers	2
Welders	3
Surgeon	1
Retired	2
Laborer	1

The first and largest group of patients in this study, clerks and accountants, will need little elaboration, as their occupational skills are almost entirely dependent upon their abilities to perform near visual

tasks efficiently and accurately. For example, a banker's livelihood depends on such skill.

Case 1

Name, D.C.K.; age, 25 years; sex, male; refractive error, hyperopia negligible; visual acuity, 20/20 O.U., prescription worn, none; occupation, accountant.

Cover Test—Distance: 0△. Near: 14△ exophoria; NPC 8 cm.

Troposcope—Distance: 0△. Near: 12△ exophoria; O.D. dominant.

Fusional Amplitudes — Convergence, 10△ B.O.; recovery point 8△ B.O.; divergence 2△ base in (B.I.).

This patient complained of extreme ocular fatigue accompanied by a burning sensation in the eyes and frequent frontal headaches associated with near work.

Case 2

Name, H.S.; age, 37 years; sex, male; refractive error, H-negligible; visual acuity, 20/20 O.U.; prescription worn, none; occupation, accountant.

Cover Test—Distance, 0△. Near, exophoria; NPC 10 cm.; O.S. dominant.

Troposcope—Distance, 2△ exophoria. Near, 8△ exophoria.

Fusional Amplitudes—Distance: convergence, 10△ B.O.; divergence, 0△. Near: convergence 6△ B.O.; divergence, 18△ B.I.

Not infrequently a patient will complain of symptoms of asthenopia, yet measurement of the deviation will reveal normal or near normal findings. If, however, the patient is placed before a major amblyoscope, or is asked to overcome base-out prisms, the examiner may often find very inadequate fusional amplitudes, especially in fusional convergence.

Sometimes a remote NPC may be an important clue to the individual's problems although this is not always so.

It has been stated that 21△ of convergence is the minimum amount of fusional convergence required to maintain good near visual comfort. I have found that this is accurate, and that an individual's inability to overcome 20△ base out on the troposcope can quite reliably be accepted as an indication of convergence deficiency, especially if accompanied by symptoms.

The students formed the second largest group of males. For the most part their complaints and symptoms correlated very closely with those of the clerks and accountants. Many of the students had made very high grades and were inclined to study long hours at a time.

These patients complained particularly of ocular fatigue, distressing drowsiness when reading, and frequent "blurring" or visual confusion. They usually came into the office seeking glasses to relieve "eye-strain," many of them having been prescribed glasses previously by other clinicians when refraction revealed a neglible refractive error and 20/20 vision.

We have found that a patient who had been wearing +0.50 to +1.00 spheres was uncomfortable both with and without them. The wearing of unnecessary "plus" spheres, especially by persons with a negligible refractive error and an exophoria, appeared to produce a change in the normal accommodation-convergence ratio and, it seems logical to assume, disturbed the balance of the convergence mechanism and brought about impairment of visual comfort and function.

Case 3

Name, W.G.; age, 19 years; sex, male; refractive error, H-negligible; visual acuity, 20/20; prescription worn, none; occupation, student.

Cover Test—Distance: 0△. Near: 25△ exophoria; NPC 25 cm.; O.D. dominant.

Troposcope—Distance, 0△. Near: 18△ exophoria.

Fusional Amplitudes—Distance: convergence 14△ B.O.; divergence 2△ B.I. Near: convergence, 12△ B.O. ; divergence, 18△ B.I.

Engineers comprised the third largest occupational group. A very common complaint among this group was "eye blur" when using a slide rule, and visual con-

fusion or occasional diplopia at near. This is a very annoying problem to persons who are required to make quick and accurate calculations.

The measurements and findings in the engineers were similar to those in other cases of convergence insufficiency, but intermittent foveal suppression of the nondominant eye was elicited in each. Teaching of physiologic diplopia quickly made these patients aware of their habits of suppression and brought about considerable relief from symptoms. Many reported alleviation of diplopia and of visual confusion after three or four sessions on the troposcope.

Precision machine operators, laboratory technicians, opticians and printers were found to have similar problems related to work distance, and they responded quickly and satisfactorily to orthoptic therapy.

The jewelers had somewhat unique problems.

Case 4

Name, C.J.L.; age, 51 years; sex, male; refractive error, hypermetropia with plus add.; visual acuity, 20/20; prescription worn, hypermetropia with bifocal add; occupation, jeweler.

Cover Test—Distance: exotropia 4△. Near: intermittent exotropia 26△.

Troposcope—Distance: exotropia 2△. Near: exotropia 22△; NPC 16 cm.; O.D. dominant.

Fusional Amplitudes—Distance: convergence, 2△ B.O.; divergence, 0△. Near: convergence, 4△ B.O.; divergence, 0△.

Remarks: Fusion was very unstable with intermittent suppression O.S. This jeweler had an intermittent exotropia for near and complained of severe symptoms of asthenopia, and was given eight orthoptic sessions with little success. It was found that throughout many years in his profession he had habitually used a "jeweler's circle" before his dominant eye while suppressing the nondominant eye. So deeply established had his suppression habit become that he was unable to maintain awareness of physiologic diplopia even on lights.

The second jeweler, a 38-year-old male, also had a convergence insufficiency. He was quickly made aware of his suppression habits, and as he had followed this occupation for not more than two years, he had little difficulty in overcoming his problems and his discomfort was quickly alleviated. He learned to use the nondominant eye with the circle, and later he acquired a binocular apparatus.

Case 5

Name, Prof. M.P.; age, 49 years; sex, male; refractive error, hypermetropia with presbyopia; visual acuity, with correction 20/20; prescription worn, hypermetropia with add; occupation, university professor.

Before treatment:

Cover Test — Distance: with correction exophoria 4△: without correction 2△; 1△ LH.

Near: with correction exophoria 20△: without correction 18△; 1△ LH.

Troposcope — Distance: with correction exophoria 2△; without correction 0△; 1 LH.

Near: with correction exophoria 24△; without correction 20△; 1△ LH; NPC 10 cm.; O.D. dominant.

Fusional Amplitudes—Distance: convergence 12△ (intermittent); divergence 8△ (Suppression O.S.). Near: convergence, 10△; divergence, 22△.

Remarks: Symptoms became acute with convergence effort.

After 8th Treatment:

Cover Test—Distance: 0△. Near: exophoria; NPC to nose.

Troposcope — Distance: with correction exophoria 2△; without correction 0△. Near: with correction exophoria 16△; without correction 14△.

Fusional Amplitudes — Distance: convergence 50-60△ B.O.; divergence 8△ B.I. Near: convergence 50△ B.O.; divergence 20△ B.I. (No evidence of suppression.)

Remarks: Patient reports that symptoms were entirely alleviated.

This history professor had symptoms which became so acutely severe that he was on the verge of giving up a brilliant and successful scholastic career. Careful correction of the refractive error failed to remove the symptoms which were actually due to convergence insufficiency. The patient, so acutely distressed by his symptoms, was willing to undergo surgery in order to obtain relief from this condition. At the time of the examination it was found that he had previously been instructed

to do "pin-to-nose" exercises, but had failed to gain relief, since he was not often aware of diplopia at his convergence "break-point" because of deep suppression.

Orthoptic treatment was instituted with office visits twice weekly, and at the end of six sessions the patient reported entire alleviation of his symptoms. Office visits were continued once a week until a total of 12 sessions were completed. The patient reported for review after three months (during which time he was doing prism exercises at home), then six months later, and finally after one year with no recurrence of symptoms.

Unstable binocularitv and convergence problems can also be very annoying to a *surgeon* who can ill afford an error of a millimeter or less when performing a delicate surgical procedure. The surgeon who was our patient derived improved visual comfort and functional skill after only a few sessions on the major amblyoscope and frequent practice of physiologic diplopia convergence exercises.

Welders occasionally suffer manifestations of convergence insufficiency associated with their work distances, whereas *unskilled laborers,* it would appear, are not as susceptible to this entity. Though not shown in this report, several unskilled laborers were observed who demonstrated some exophoria with poor convergence but did not complain of symptoms.

Of the two *retired* men, one had been a farmer and the other a railroad workman. Having ceased to engage in active physical occupations, they began to have difficulties and symptoms after turning to reading for a pastime.

A study of the female patients who received occupational orthoptics shows that their objective and subjective symptoms and findings bear a close correlation with those of the male patients.

AGE DISTRIBUTION OF 58 FEMALE PATIENTS

AGE IN YEARS	NUMBER OF PATIENTS
0 - 20	10
21 - 30	20
31 - 40	13
41 - 50	9
51 - 60	6

OCCUPATIONAL DISTRIBUTION OF 58 FEMALE PATIENTS

Secretaries and clerks	29
Housewives	21
Students	4
Comptometer operator	1
Industrial nurse	1
Physician (anesthetist)	1
Beautician	1

For the sake of brevity, and to avoid repetition, a study of each occupational group will not be reported. However, it is interesting to note that "housewives" form the second largest female group. The majority of these patients (ranging in age from 20 to 60 years) complained of symptoms of asthenopia especially when sewing, crocheting or reading. We find that the housewife actually requires a very complicated visual pattern for her many skills; reading, using a sewing machine, working at tables, piano playing, all require different work distances. Even in this modern age of automatic household gadgetry and television, the housewife needs to spend much time at all of these occupations.

The group "secretaries and clerks" is one which will be familiar to all. In many busy offices the secretaries and clerks must spend long hours balancing figures, posting ledgers, typing lengthy reports and doing miscellaneous reading tasks which would certainly tax to the maximum any unstable binocular mechanism and aggravate a convergence deficiency.

As a matter of interest, the industrial nurse shown in this study had used a monocular microscope for the past two years and had developed a very deep suppression habit. Her problem was one strikingly similar to that of the second jeweler mentioned in the male group, and she was equally responsive to treatment.

SUMMARY

It is interesting to point out that while other observers have indicated a pre-

ponderance of females among patients with convergence deficiency, it can be noted that among the 126 patients presented here, 86 were male and 58 female. The sex of the patient bears little, if any, significance to convergence insufficiency.

Varied occupations demanding sustained "near" binocular vision and in which a great deal of "flexible" near visual function is required in greater or lesser degree of convergence and accommodation, are significant in contributing to symptoms when there exist in the individual inadequacies of fusional convergence.

As the individual reaches adulthood, new or different demands are placed upon his convergence mechanism. If this mechanism is functionally inadequate to meet the demands of these new or different near visual tasks, impairment of visual comfort may well manifest itself in symptoms of asthenopia. The tensions, pressure, and speed in an industrial area add to the problem.

The view that convergence tends to suffer from disuse is indeed a very interesting point. In dealing with a patient, one frequently may wonder whether he had, at the very earliest onset of his ocular symptoms, deliberately inhibited convergence whenever possible.

The over-all results of orthoptic treatment of patients with complaints closely related to their occupational needs have been most gratifying. It is a most interesting and satisfying field of orthoptic endeavor, and one frequently overlooked. The gratitude of the patient whose symptoms have been relieved, and whose near visual tasks have been made comfortable, is indeed rewarding to the technician, and the cure is of great benefit in helping the patient to support his heavy responsibilities.

VERTICAL MOTOR ANOMALIES

WEBB P. CHAMBERLAIN, JR., M.D.
CLEVELAND, OHIO

IT is the purpose of this paper to present some aspects of vertical motor anomalies that may be of importance to the orthoptist. I shall emphasize the methods of testing which I have found helpful, and I shall illustrate typical cases of vertical anomalies with a motion picture film.

In the very beginning I should state that vertical anomalies do *not* lend themselves to correction with orthoptic exercises. This would seem quite obvious, but I do know of instances in which time and effort have been wasted by an orthoptist attempting to benefit vertical deviations by exercises. Of course, these vertical anomalies are usually treated either surgically or with prisms.

It is apparent, however, that the orthoptic technician must be thoroughly conversant with the methods of examination and with the problems involved in the management of these cases. As we all know, even a minimal vertical deviation may constitute an insurmountable obstacle to fusion. Pure vertical anomalies are rather infrequent as compared with those occurring in combination with horizontal squint. I would agree with those who state that a small vertical element is often the causative factor in a major horizontal strabismus.

The function of the vertically acting muscles is sufficiently complicated that occasional clarification may be in order. The study of the excursions in the cardinal positions is fundamental. If only one test were permitted, I believe that properly executed and carefully observed excursions in the six cardinal positions would supply more information than can be obtained by any other single method.

In performing excursions to check the individual vertically acting muscle, I strongly prefer, first, to move the eyes horizontally to the proper position of abduction or adduction, and then to test elevation or depression from this secondary position. For example, in investigating the superior rectus, the first movement is one of temporal rotation by the lateral rectus in the horizontal plane to a secondary position at which elevation can be effected by the superior rectus alone. Thus the eyes are moved "out and up" and not "up and out" or along an oblique course, as is commonly stated.

In considering monocular rotations we know that pure elevation or depression by the vertical recti is obtained only with abduction of about 23 degrees, but pure elevation or depression by the obliques requires a theoretical adduction of about 51 degrees. However, in clinical testing, observation of the binocular rotations is more important, and in this case we compromise on a practical angle of about 35 degrees. We must keep in mind, therefore, that binocular excursions in the cardinal positions actually do not check pure function of the vertical rotators.

Measurement with prisms in the cardinal positions receives varying emphasis in different sections of the country. I believe that this is definitely a valuable method of examination in vertical anomalies. However, there are obvious limitations to this procedure, especially in young children and in patients whose prolonged cooperation is not readily obtained. Furthermore,

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the mechanical difficulties are considerable, particularly in the lower fields of gaze because the lids must be held in the elevated position and a prominent nose may interfere with binocular fixation.

I prefer an arrangement such as Owens has devised in the deviometer. This consists in a standard head rest, which holds the head solidly in place, and a fixation light on a swivel arm. This setup places the fixation light at the proper distance and at a comparable angle with relation to the straight-ahead position, as the light is shifted into the different directions of gaze. Such an instrument facilitates the performance of the test and standardizes the procedure so as to permit more reliable comparison of measurements on successive examinations. If the light is simply held by the patient or an assistant, variations in the successive positions of this fixation light may alone be sufficient to make the findings of questionable value.

Diplopia fields are occasionally very helpful in the diagnosis of vertical motor anomalies. It is important to remember that the more peripheral image always belongs to the affected eye. Diplopia fields have the disadvantages of any subjective test that requires intelligent cooperation on the part of the patient. They are not applicable in young children, and they cannot be used when there is suppression or anomalous retinal correspondence. In addition, the procedure of taking diplopia fields becomes unwieldy in marked deviations, for the separation of the images is too great to fit on the usual screen. For these reasons I usually place more reliance on the objective methods of testing.

In vertical anomalies the concept of primary and secondary deviation is particularly important. The fixing eye must always be identified, and it is especially significant whether fixation is maintained with the sound or with the paretic eye. When the nonparalyzed eye fixes, the deviation is primary in type; whereas, when the paretic eye is used for fixation, the deviation is secondary. The primary deviation with the sound eye fixing is always less than the secondary deviation with the paretic eye fixing.

In explaining primary and secondary deviation, Sherrington's law of reciprocal innervation and Hering's law of equal innervation are of basic importance. Fixation is easily maintained by the sound eye, and normal and equal innervation goes also to the paretic eye which lags moderately, giving a primary deviation. However, when the paretic eye fixes, an increased stimulus is necessary to hold this fixation and an equally increased innervation goes to the yoke muscle of the sound eye, resulting in the secondary deviation. For example, if the right superior rectus is paretic and fixation is with the right eye, there may be a marked secondary deviation of the yoke muscle, the inferior oblique of the sound left eye. However, if the sound left eye fixes, there may be only an inconspicuous lag—a primary deviation in the field of the paretic right superior rectus.

Perhaps some of the disagreement as to the relative incidence of superior rectus paralysis and superior oblique paralysis may be resolved by the increasing recognition of so-called primary overaction of the inferior oblique that is present only on extreme excursions. I would agree with Adler that this type of overaction is due to the greater strength of the inferior oblique as compared with its direct antagonist, the superior oblique. This is not an indication of any muscle paralysis. Scobee attributed this in part to the longer effective portion of the inferior oblique and its greater arc of contact. Typically, these cases show no vertical deviation in primary position and the patients do not complain of diplopia. However, on extreme adduction, at the point where the adducted eye is screened by the bridge of the nose there may be a definite upshoot of variable degree.

Thornwall Davis called our attention to the two important signs of paralysis of

the superior oblique. They are (1) torticollis or habitual tilting of the head to the side opposite the paralysis, and (2) the upshoot of the paretic eye when the head is tilted to the paralyzed side.

Particularly in long-standing paralyses in which there has been a spread of comitance, it is often difficult even with the most careful prism measurements to detect a significant difference between the upper and lower fields. Coupled with this is the problem of accurately measuring with prism and cover in the lower fields of gaze. Particularly with uncooperative youngsters, any prop that assists in establishing a positive diagnosis is most welcome.

The use of prisms in the treatment of hyperphoria is a subject with which orthoptists should be familiar. Of course, it is the smaller deviations that lend themselves to correction with prisms, and it is primarily those that are reasonably comitant.

In measuring these smaller deviations, the Maddox rod test is ideal. It is important that the deviation be checked at 20 feet and at 16 inches, preferably in the lower field corresponding to the reading position. I believe that there is no rule of thumb which is safe in the prescription of vertical prisms. In general, however, the deviation present for near fixation must be more fully corrected, and it is obvious that the important deviation is that elicited when the preferred eye fixes. Usually a minimum of vertical prism is employed.

I am concerned not so much with measurements as with the patient's section, both for distance and near. This I would call the "prism acceptance" of the amount of prism that the patient seems to prefer. For example, if there is a Maddox rod measurement of two diopters of right hyperphoria for distance and near, I usually have the patient observe the 20/25 line with his best refractive correction before each eye. I then offer him a one-diopter prism base down over the right eye, asking if this makes the line more solid and single as I introduce the prism or as I take it away. He may say, "I see double for a moment when you add that lens." I then repeat the process, saying, "Does the line of letters become single more rapidly as I put it on or as I take it off?" If he prefers this one-diopter base-down prism, I try the same procedure, adding or subtracting a half-diopter prism to that already present in the trial frame. The process is then repeated for near. As a general rule, prisms are kept at a minimum, but a more complete correction is usually employed for the hyperphoria present at close range. If the patient says that he cannot tell whether the prism is added or not, no prism is ordered, regardless of the deviation measured with the Maddox rod. It is wise to repeat the prism-acceptance test at a second visit. The proper use of prisms is an important factor in the management of vertical motor anomalies, and the orthoptist who works with an ophthalmologist may be of great help in assisting with these examinations.

In conclusion, I find vertical motor anomalies to be most interesting and challenging. Although they do not lend themselves to corrective exercises, the orthoptist should be thoroughly familiar with the diagnostic tests and with the various methods of treatment.

AIDS IN ORTHOPTIC TREATMENT

B. EVELYN TAYLOR, O.T.
NEW YORK, NEW YORK

THE title of this paper may lead you to believe that I have stumbled upon the keys to something revolutionary in the solution of our many orthoptic problems. I wish the answer could be a definite yes. We all have certain pet devices, along with the usual techniques, which appear to help us to resolve the particular situation at hand. It is hoped that in my presentation of some of the devices used in our office, you will find a suggestion which will be advantageous in facilitating treatment of some of your individual cases.

We are all aware that some patients have difficulty in appreciating the superimposition of a red and green light while wearing the regular red and green diplopia glasses. If this confusion occurs, especially when the patient is a small child, we use similar diplopia goggles[1] with a cylinder of plus 1.50 at axis 180 ground into the red glass.* By moving the glasses rapidly up and down in the vertical plane, the red image will be seen to move in and out of the green image. This technique requires a subjective response and also provides an objective check of the patient's reliability and veracity. A cylinder taped to the back of the red glass in any pair of red and green diplopia goggles should serve the same purpose.

*The red prism bar** has proved a definite asset when we are attempting to create awareness of diplopia in some patients. This bar has been particularly useful when it is used along with divergence and convergence exercises while the patient is remaining stationary or when he is advancing toward or receding from a light.

Another small and handy instrument is the *red multiple Maddox rod* with 0.75△.*,[2] The need for this particular Maddox rod became apparent after considerable difficulty had been experienced in obtaining a Maddox rod without an undesirable prism of varying strength. The base of the prism is at right angles to the rod image and the small handle is in line with the streak image. By the use of this rod one can quickly and easily study small vertical deviations and low degrees of lateral imbalance.

Approximately two years ago, Dr. Conrad Berens had a set of *plastic clip-on prisms*[*,4] made for use in the office. These prisms have proved invaluable in many ways. In the first place, they are much lighter in weight than the usual glass prisms, are difficult to break or chip, and can be resurfaced when they become scratched. Being round in shape, they will fit any standard trial frame and will fit the cells of most cheiroscopes. Through the use of these prisms we have had increased success in the treatment of many of our patients who have a small-angle squint. These prisms are particularly valuable postoperatively in patients who have normal retinal correspondence, some amplitude of fusion on the major amblyoscope, and an awareness of diplopia. Suppression and reacceptance of anomalous retinal correspondence are prevented in the majority of cases, and the patient is thus encouraged to carry on with his orthoptic program.

The set consists of prisms in pairs ranging in strength from 1△ to 6△. Four lightweight clip-on frames in two sizes are included in the set, also a small screwdriver for use by the physician or technician in setting and adjusting the prisms at the

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correct angle. In general, the required position of the prism is base in, base up, base out, or base down. However, there are times when a combination of two prisms with their bases at right angles to each other is desired.

As you are aware, any such combination of prisms is equivalent to a single prism with its base at an intermediate position and of a power equivalent to the resultant of the two component prisms. If one is a member of the "Do It Yourself Club" or is intrigued by the subject of optics at all, solution of such a problem can be fascinating and actually arrived at very easily through use of a simple chart described in Dr. Berens' book The Eye and Its Diseases,[3] in the chapter entitled "Principles of Refraction and Elementary Optics."

Greater familiarity with the use of prisms will be rewarding to the technician, particularly when the services of an optician are not readily available. Incidentally, with regard to the clip-on frames, you may be interested to know that monocular clip-ons* are now available at a very nominal fee. These monocular clip-ons should prove to be an asset when a small vertical deviation interferes with the patient's progress toward stable fusion with amplitude. These monocular clip-ons may well be the answer to the problem of wearing clip-ons over the various stylized frames so prevalent today.

More recently, we have found the use *of plastic spheres** in clip-on frames pleasing to our patients. Again, because of their lightness in weight, children, in the process of dissociating their accommodation and convergence, rarely object to wearing them constantly. The set consists of plus and minus spheres in pairs ranging from 0.50△ to 3.00△.

If any of your ophthalmologists has a Berens cataract-head attachment*,[7] for his flashlight, you will find it to be excellent for holding the attention of the patient while you are obtaining near measurements. The head has two 1 mm. and two .5 mm. apertures through which one or two white lights may be seen. Added interest is provided when red and green glasses are worn. Small children particularly are interested in "looking" when permitted to turn the head of the instrument which governs the size, color and number of lights which they will see.

We have been using *Berens' Stereoscopic Cards in Color, Series C*†since 1952. Designed to stimulate interest in and desire for fusion, they are suitable for use by adults and children of any age. Through the courtesy of the Walt Disney Company, many of the familiar objects, animals and characters are depicted in bright, attractive colors. These figures hold the observer's attention better than do the usual black and white ones. The cards may be used in hand or other types of stereoscopes, junior and senior models of the correcteye-scope, and the rotoscope. They may also be used without instruments. This is done by arranging the selected cards on the table and placing the hands on each side of the nose to form a septum. These cards may be used advantageously for determining the presence of first, second, and third grade binocular vision, the presence of lateral and vertical heterophoria, and the presence of high degrees of aniseikonia. When normal correspondence is present, the cards provide a valuable therapeutic means of developing and improving first, second, and third grade binocular vision as well as lateral, and possibly vertical, amplitude of fusion.

Finally, I should like to describe an *exercise for divergence during accommodation.*[6] This is a simple technique using an accommodation card,**,[5] plus and minus spheres and a prism bar. Many patients with a heterophoria are unable to fuse when accommodating on small print, but

†Printed and distributed by American Optical Company.

**Available at Ophthalmological Foundation, New York City.

have a fair to good amplitude of fusion with prisms when fixating on a 3 mm. white-headed pin or light at 25 cm. These patients, usually young children, are frequently found to be slow readers and to manifest an overconvergence in ophthalmographic studies, particularly when shifting fixation to the next line of print. Each patient is given a plastic accommodation card with letters, numbers and E's graduated in size, and is instructed to fixate the word, number or E which he can fuse while accommodating (for example, a single letter of 1 M print). If correction has been indicated, glasses should be worn during the early period of training, especially if lenses are prescribed to lessen the accommodative effort at near. This correction includes plus spherical clip-on lenses or bifocals. If the patient can fuse the 1 M print successfully, he is next instructed to fixate the 800 MM print. As the patient's ability to maintain fusion while accommodating improves, the size of print is gradually reduced until the 30 mm. print can be read. At this time, except in cases of presbyopia, the additional plus correction used for close work may be gradually reduced, and often dispensed with entirely. To dissociate accommodation and convergence still further, the patient is encouraged to overcome the effect of minus spheres of increasing strength up to —3.00△. Finally, exercises for divergence are given, using a prism rack to introduce base-in prisms while the patient is accommodating on the finest print which he can read. In some cases base-in clip-on prisms are prescribed for short periods of reading.

*All materials marked thus were manufactured by R. O. Gulden, Philadelphia.

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STEREOSCOPIC CARDS IN COLOR FOR VISUAL AND ORTHOPTIC TRAINING

CONRAD BERENS, M.D.
VIVIAN BRACKETT, R.N.
B. EVELYN TAYLOR, O.T.
JEAN ZERBE

NEW YORK, NEW YORK

ORTHOPTIC training has been universally accepted by the majority of ophthalmologists as one method of attempting to restore normal binocular vision and develop stereopsis in adults and, especially, in children.

With the advent of three-dimensional motion pictures, the incentive to obtain binocular vision is increased, and greater cooperation may be secured from the individual in his effort to obtain stereopsis. Since the training is usually long-range, the targets must be interesting in order to stimulate the observer's desire to improve his fusion and ocular coordination. It was with these points in mind that Series C of Stereoscopic Cards in Color was developed for use particularly when young children are to be trained.

This new collection of stereoscopic cards combines the best features of the previously published A and B series[1, 2] with additional cards in color. Designed to stimulate interest in, and the desire for, fusion, they are suitable for use by adults and children of any age. Familiar objects, animals and characters are depicted in bright, attractive colors which holds the observer's attention more than the usual black and white cards. The cards may be used in any kind of stereoscope, junior and senior models of the correcteyescope, and the rotoscope. The cards may also be used without instruments; this is done by arranging the selected cards on the table and placing the hands on each side of the nose to form a septum.

Series C may be used advantageously for determining the presence or absence of first-, second- and third-grade binocular vision, and for determining either the presence of lateral and vertical heterophoria or the presence of high degrees of aniseikonia. Through graded exercises, these stereoscopic cards provide a valuable therapeutic method of developing and improving first-, second- and third-grade binocular vision, as well as lateral and possibly vertical amplitude of fusion, in patients with heterophoria and heterotropia. It is understood that normal retinal correspondence is a prerequisite for fusion training with these cards.

Cards 1 and 2 are for diagnostic purposes only. They are used to determine whether simultaneous binocular perception is present, to ascertain the optimum fusion separation, and to discover the presence of any vertical imbalance. A millimeter scale card has been included, which may be used for holding the cards in a hand stereoscope and for measuring the amplitude of fusion.

The first stage of training is directed toward stimulation of simultaneous use of the two retinal images (superimposition or first-grade binocular vision). Dissimilar targets such as 4 and 4A (fig. 1) are used. When the observer can see a single picture of the monkey in his cage and can read

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Cards are distributed by the American Optical Company, Catalogue No. 13395.

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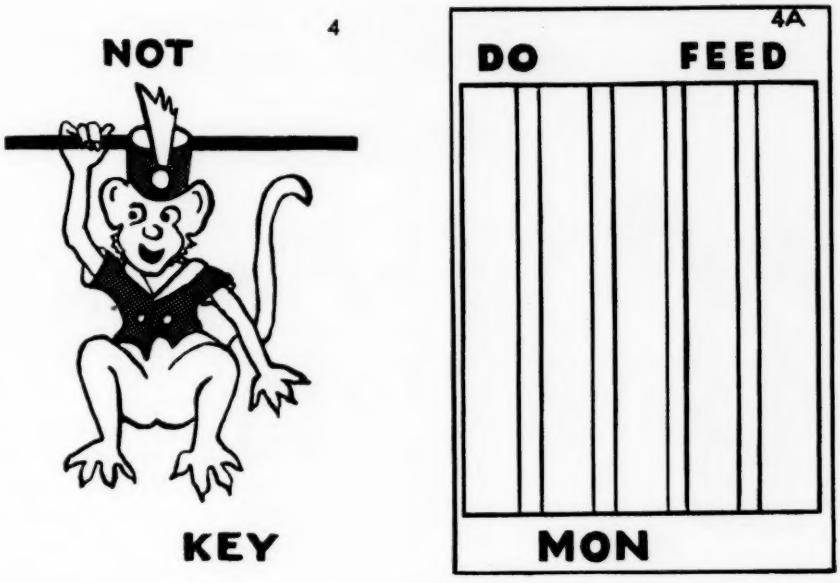

FIG. 1—Cards 4 and 4A depict monkey and cage, both attractively colored. In order to place the monkey correctly in the cage, the observer must have first-grade binocular vision.

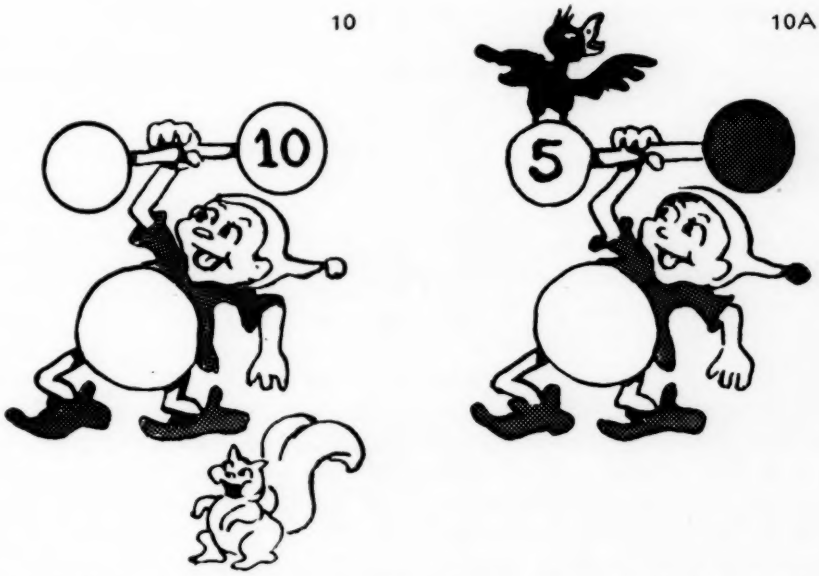

FIG. 2—Cards 10 and 10A. Elf lifting weights, in color. This card is used in testing and developing second-grade binocular vision. The special controls aid in checking the observer's ability to fuse.

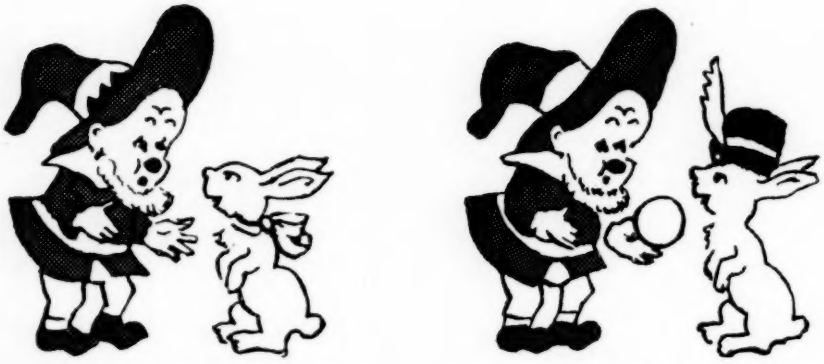

FIG. 3—Cards 21 and 21A. Displaced rabbit, in color. This card is used to determine the absence of, or presence and quality of, stereopsis.

"do not feed monkey," first-grade binocular vision is present. First-grade vision should be firmly established before proceeding to the second stage of the exercise, which is directed toward the establishment of fusion with amplitude.

To encourage and improve second-grade fusion, pairs of cards depicting a common element with differentiating check marks are used, such as 10 and 10A (fig. 2). The observer should see the elf lifting a red and green weight, with a black crow perched on the green ball and a squirrel on the ground. Exercises to increase the amplitude of fusion are provided by separating the cards temporarily (diverging exercise) or approximating the cards (converging exercises) while fusion is maintained.

Third-grade fusion, known as stereopsis or depth perception, is the ultimate goal. Similar cards, slightly decentered, are used at this stage in the training program. When the observer can appreciate the relative positions of the objects seen in the fused picture, depth perception is present. When using cards 21 and 21A (fig.3) with 21 on the left and 21A on the right, the elf appears to be in front of the rabbit. Reversing the cards causes the rabbit to appear closer to the observer.

Series C of Stereoscopic Cards in Color consists of 24 sets of cards and includes complete and clearly written directions for use.

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We gratefully acknowledge the generosity of The Walt Disney Company for permission to include some of their well-known characters, which add greatly to the interest of the cards. We also thank Miss Patricia Rainier for her interest and skill in making the drawings.

REVIEW OF CONVERGENCE AND DIVERGENCE MECHANISMS

FRANCIS HEED ADLER, M.D.
PHILADELPHIA, PENNSYLVANIA

ALTHOUGH the orthoptic technician is primarily concerned with the sensory aspects of strabismus, she should be familiar with the motor mechanism which moves the eyes, since disturbances of this mechanism are the primary cause of strabismus. Except for those cases in which the strabismus is caused entirely by paralysis of a muscle or muscles, the motor deficit is necessarily concerned with the disjunctive movements of the eyes, i.e., convergence and divergence. Indeed, in many cases of primary muscle paralysis of the vertically acting muscles, an excessive convergence or divergence tonus creates an esotropia or exotropia which hides the original sinner in the picture; namely, the vertical muscle which is paretic.

We have good reason, therefore to review some of the facts known about the disjunctive movements of the eyes. This is especially true, since recently we have acquired convincing evidence of the presence of a separate divergence mechanism.

CONVERGENCE

Convergence is primarily a reflex activity. Only a few people can converge the eyes voluntarily, i.e., without having some fixation point close to the eyes. The moment one introduces an object on which to fixate, a reflex activity is introduced, the components of which depend upon the characteristic of the fixation object. To be purely voluntary, convergence must be accomplished without the aid of any visual stimulus. As we shall see, the reflex nature of convergence is complex and consists of several factors usually working together. Before we can advantageously analyze these various components of convergence, it might be wise to take a broad look at the mechanism which moves the eyes in conjugate gaze, for many of the problems of the disjunctive mechanism are similar.

The conjunctive movements, or versions, consist of those initiated voluntarily and those of reflex origin. Actually, all movements are a composite of each, since all voluntary movements have to be smoothed out in time and extent by reflex tonus. It is important to distinguish between the two because they rely on anatomically separate mechanisms, and we occasionally see patients with a deficit in one but not in the other mechanism. In normal life, however, these two mechanisms work together simultaneously to produce coordinated, finely balanced movements of the two eyes so that the foveas are directed on the object of regard.

All voluntary movements result from impulses arising in the frontal cortex in areas 8 alpha, beta, and gamma. They are conveyed by fairly well-known pathways into the midbrain, where they are distributed to the nuclei of the oculomotor nerves concerned in the desired movement. The mechanism in the midbrain acts very much like the central switchboard in a telephone system; it automatically links up the various muscles needed to perform any desired movements of the eyes.

Although we say dogmatically that all voluntary movements originate in the frontal cortex, we have fairly complete information about horizontal move-

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ments only, for vertical movements cannot be elicited by stimulating the frontal cortex on one side alone. In man it has obviously not been possible to perform experiments in which both sides are simultaneously stimulated, although much work has been done on unilateral stimulation, and the results correlated by Penfield and his co-workers. We have reason to believe, however, that the vertical movements do come from this region when voluntarily produced, and that convergence does also when it is voluntarily initiated. Strangely enough, divergence, which cannot be produced voluntarily by anyone, has been elicited in monkeys by stimulation of certain portions of the frontal cortex, although in the same animal it is not possible to elicit convergence movements.

In addition to the voluntary movements produced by impulses arising from the frontal cortex, nerve impulses influencing the tonus of the ocular muscles are constantly being sent into the central regulating mechanism in the midbrain from the whole body in response to changes in its environment. Some of these impulses are well known to us, such as those from the vestibular apparatus, i.e., the otoliths and the semicircular canals. Others, such as proprioceptive impulses from the ocular muscles themselves, are known, but their importance in man is at present being debated.

The chief reflex activity which modifies the activities of the muscles of the eyes, in both conjugate and disconjugate movements, arises from the visual impulses themselves. The images on each retina send up messages to the brain, which eventually arrive in the occipital lobes around the calcarine fissures. This area, known as the striate area (from the fact that there is an additional white stripe which can be seen with the unaided eye in cut sections of the cortex around the fissure), is the end station for the impulses which originate in the rods and cones. But the striate area connects with the immediately surrounding areas in which there are motor cells which connect up with the central oculomotor switchboard. As the pattern of activity from the various portions of the retina is received in the calcarine cortex, the tonus of the ocular muscles is changed and automatically produces movements designed to make the eyes move together so that the foveas of the two eyes remain fixated on the object of regard. In this manner, fixation movements, following movements, and so-called fusional movements are produced. In fact, this mechanism is the motor counterpart of fusion, and when you speak of fusion from the standpoint of the sensory unification of two images, you should keep in mind that this is only possible in the presence of an adequate reflex motor mechanism which automatically keeps the images on photoreceptors in the two eyes falling within Pannum's areas, i.e., areas in which sensory fusion is possible.

All of the reflex activity which comes from sources other than the visual impulses we group together in the class known as postural reflexes, since in general they have to do with changes in posture of the animal. All those reflex activities which come from the visual impulses we group together in the class known as the optomotor reflexes.

To return now to our main subject of convergence, we have seen that convergence can be produced voluntarily by impulses originating in the frontal cortex, and reflexly by postural and optomotor reflexes. We know very little about the postural reflexes of convergence, and yet they are extremely important to us in strabismus. In this group belongs the so-called "tonic convergence" or the basic tonus of the convergence mechanism. You are well acquainted with the fact that the subcortical center for convergence is thought to be Perlia's nucleus, an unpaired group of cells lying between the Edinger-Westphal nuclei. The basic tonus of this nucleus probably controls the amount of

convergence tone to the medial recti muscles at all times when other reflex impulses do not enhance or inhibit it.

In most infants the tonic convergence is excessive. As long as the other optomotor reflexes work, they keep this excessive convergence in check, and the eyes are held in strict alignment. When they fail, i.e., when the eyes are dissociated by any sensory obstacle, the excessive tonic convergence of childhood makes itself manifest, and the result is a convergent comitant strabismus. This type of strabismus is not very common and is usually easily recognized, but occasionally someone makes a slip and fails to see in an eye a unilateral cataract, a macular coloboma or a macular choroiditis, retrolental fibroplasia, or worse yet, a retinoblastoma, which has dissociated the eyes by eliminating the optomotor reflexes and has allowed the excessive postural tonus of childhood to turn this eye in.

The optomotor components of convergence are accommodational convergence and fusional convergence. The former is the amount of convergence tone induced by each diopter of accommodation. This is excessive in some children, and added to an excessive tonic convergence it may be sufficient to dissociate the eyes and produce an esotropia. This is the common garden variety of accommodative strabismus.

Finally, we must consider the component which most authors now call "fusional" convergence. This is the component of convergence which you hope to influence through orthoptic training. The theory is that by practice you can increase the "desire" for fusion, i.e., "fusional convergence," so that it will hold in check both the tonic convergence of childhood and accommodative convergence. How successful you are in achieving this desired result and its effect on the stabilization of proper alignment of the visual axes is attested to by your literature. There is no doubt in my mind that this is the most important and successful part of orthoptic training, but it is generally applicable only to those cases of comitant esotropia or exotropia which have an accommodative basis.

At the beginning of this lecture I spoke about comitant esotropia developing on the basis of paralysis of a vertically acting muscle. If the eyes become dissociated because of a vertically acting muscle, the dissociation allows the excessive tonic convergence of childhood free play, with the result that what appears to be a comitant esotropia develops. The vertical muscle palsy is frequently overlooked. No treatment will be successful in achieving alignment of the visual axes and sensory fusion until the vertical muscle deficit is remedied by surgery. Only too often these cases are overlooked and given orthoptic training with not only disappointing but sometimes disastrous results, in that they break up the child's only protective mechanism against diplopia, namely suppression. Such training should obviously only be undertaken when it has been ascertained that the visual axes can be brought into good alignment so that the fusional reflexes will be able to hold the eyes together.

DIVERGENCE

Divergence must be largely a reflex activity. Until recently the very existence of a divergence mechanism was hotly debated. Scobee, for example, denied that the act of divergence of the visual axes from convergence to eyes straight ahead was an active process; he claimed that it was merely inhibition of convergence. The assumption of parallelism, he stated, was due entirely to the elasticity of the lateral rectus muscles and the orbital fascia. During convergence these were put on a stretch, and when the medial rectus muscles relaxed, the elastic pull of the lateral recti brought the eyes back to parallelism. This theory did not go unchallenged, and it was pointed out that many things suggested the existence of a separate mechanism for diver-

gence, such as cases of divergence paralysis as well as intermittent exotropia, which could not be well explained on the basis of relaxation of convergence.

A few years ago we brought out some physiological evidence of the existence of a divergence mechanism by showing that the electrical impulses in the lateral rectus muscles increased during divergence, and that the burst of electrical activity actually preceded the movement of the globe. This could only mean that an increase in tonus was sent to the lateral rectus muscles from a divergence center, similar to that sent down to each medial rectus muscle during convergence from Perlia's nucleus.

I must admit that instead of making things easier for us this has considerably complicated the problem. Instead of thinking of esotropia in terms of convergence alone, we now have to think also in terms of diminished divergence. Either an increase in convergence tonus or a diminution of divergence tonus may give rise to a persistent inturning of the visual axes. This must not dismay us, however, and it may well be that as we learn more it may clear up difficulties which are now posed when we consider a convergence mechanism alone. I believe that it logically explains cases of intermittent exotropia in which convergence is normal at the start, and the deviation of the eyes from parallelism only occurs for distance when the eyes are sensorially dissociated. Evidence that this is indeed due to excessive divergence tonus has recently been obtained by Dr. Breinin in New York, using electrical recording methods similar to ours.

As our knowledge of the motor mechanism for ocular motility increases, you may be assured that the orthoptist's armamentarium will increase and her usefulness expand. It will be a challenge to each of you to keep abreast of the developments in this field, and to be on the alert to see whether such developments cannot solve some of your present problems.

ACCOMMODATION AND CONVERGENCE

EDMOND L. COOPER, M.D.
DETROIT, MICHIGAN

THE end result of normal binocular development is clear and single vision at all distances and in all directions of gaze. When obstacles occur which prevent normal binocular development, strabismus results. Kinetic obstacles are those which affect the accommodation-convergence relationship.

Under normal conditions every accommodative effort is accompanied by a proportional convergence effort. Accommodation provides clear vision and it may be measured, the unit of measurement being the diopter. One diopter of accommodation is required at 1 meter, 2 diopters at .5 meter, etc. Convergence provides single vision by the two eyes and it also may be measured. One method of measurement is by means of the meter angle. One meter angle of convergence is required at 1 meter, 2 meter angles at .5 meter, etc.

Thus, accommodation and convergence are closely related and the relationship is normally in the neighborhood of 1:1; that is, 1 diopter of accommodation and 1 meter angle of convergence are required to provide clear and single vision at 1 meter, 2 meter angles and 2 diopters at .5 meter, etc.

This relationship between accommodation and convergence is not rigid and may be altered. For example, the occurrence of hypermetropia presents the necessity for an adjustment in the normal 1:1 ratio. Most hypermetropes do not overconverge because they make this adjustment. The adjustment is made by altering one function while keeping the other constant. This maneuver is known as "dissociation" and is accomplished by exercise of relative accommodation or relative convergence.

Relative accommodation is that amount of accommodation which may be exercised while convergence is kept constant. It is determined by means of concave and convex lenses placed before the two eyes. That amount of relative accommodation which can be exercised in excess of convergence is known as the positive portion of relative accommodation (relative fusional divergence) and is measured by determining the strongest concave lenses which can be overcome by the accommodation effort of the two eyes while keeping convergence constant.

Relative convergence is that amount of convergence which may be exercised while accommodation is kept constant. It is determined by means of base-in and base-out prisms. The largest base-out prism which convergence effort can overcome and still maintain clear single vision at any given distance is a measure of the positive portion of relative convergence, and the largest base-in prism which can be overcome is a measure of the negative portion of relative convergence (relative fusional divergence).

Dissociation of accommodation and convergence in accommodative esotropia is accomplished by exercise of relative fusional divergence.

Hypermetropia does not always result in esotropia because most hypermetropic individuals dissociate. Some hypermetropes do develop esotropia because they cannot or will not dissociate. If they *are* willing, they may be unable to dissociate because (1) the hypermetropia is too large, (2) the relative fusional divergence is not sufficient (these patients are those in whom an accommodative esotropia exists with a small refractive error), or (3) the accommodation-convergence ratio is abnormal, e.g., 1A:3C (normal 1A:1C). These patients may be able to dissociate for distance but not for near and will require bifocals.

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CONVERGENCE INSUFFICIENCY; ITS FREQUENCY AND IMPORTANCE

ZELDA KRATKA, O.T.
WILLIAM H. KRATKA, M.D.
WILMINGTON, DELAWARE

IN the process of doing muscle balance tests as an integral part of our routine eye examinations, we have found numerous cases of convergence insufficiency. Of 500 patients examined, 125 (25 per cent) had measurements indicative of convergence insufficiency. Seventy-five per cent of these 125 patients also had symptoms of convergence insufficiency. Judging from these figures, it appeared to us that the frequency and importance of convergence insufficiency have been underestimated. We believe that most ophthalmologists would estimate its incidence in routine examinations to be closer to 5 per cent.

Classical Convergence Insufficiency

Most of us are agreed that in the classical case of convergence insufficiency there are a remote near point of convergence, exophoria at near (with normal measurements at far), and decreased prism convergence ability (frequently with excessive divergence).

The following norms for the classical triad in convergence insufficiency were decided upon after careful evaluation of this series of 500 cases.

I. Near point of convergence

Age (years)	NPC (mm.)
Under 20	30-65
20-40	65-100
Over 40	100-125

II. Maddox rod measurements
At 6 meters: 3△ esophoria to 3△ exophoria
At 33 cm.: under 8△ exophoria

III. Vergences
At 6 meters: convergence, 16/12; divergence, 8/6; ratio, 2 to 1
At 33 cm.: convergence 22/16; divergence, 18/14; ratio 1 plus to 1

We should like to point out, however, that only 50 per cent of our cases of convergence insufficiency fitted into the classical picture. In the remaining 50 per cent only one or two abnormal findings were recorded, and they could easily have been overlooked had just one measurement been taken. In evaluating the relative importance of the components of the triad of the textbook picture in our cases, we found abnormal Maddox test findings in only 40 per cent, remote NPC in 60 per cent, and decreased prism convergence or poor amplitudes in 80 per cent. From these results, we conclude that (1) the measurement of prism vergences is the most important (but undoubtedly the most neglected) part of a routine eye examination; and (2) it is essential to consider all three factors in arriving at a diagnosis. In our asymptomatic cases we noted that a remote NPC and/or a large exophoria at near was counterbalanced by excellent prism vergences, as well as by good amplitudes on the synoptophore. In symptomatic cases, normal Maddox test findings were usually accompanied by a remote NPC with poor vergences.

The Convergence-Divergence Relationship

There has been much controversy on the subject of the normal relationship of convergence to divergence. In the literature we have found the following ratios of convergence to divergence quoted by the respective authors:

Berens:	2 to 1
Peter:	3 to 1
Scobee:	3 to 2 plus
Abraham:	1 to 1 plus
Sugar:	1 to 1 plus

In our 500 cases, we found an average

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convergence-divergence ratio of 1 plus to 1 at 33 cms., the usual measurement being approximately 20/16 convergence to 18/14 divergence. In 85 per cent of these cases the convergence measurement was greater than the divergence measurement. To further emphasize this finding, of our 125 cases of convergence insufficiency, 50 per cent (63 cases) showed greater divergence than convergence; 85 per cent of these 63 cases were symptomatic.

Occupation and Convergence Insufficiency

The patient's occupation is a definite factor in convergence insufficiency. Occupations of clerical workers, scientists, students, etc., which require constant use of eyes for close work, give rise to the greatest number of cases. The unusual number of housewives (who, in general, do not use their eyes excessively for close work) with marked symptoms appeared to be due to uncorrected myopia, failure to wear the prescribed refraction, or infrequent refractions. These factors could be classified as due to female vanity or self-neglect.

Age and Convergence Insufficiency

The highest percentage of convergence insufficiency cases were in the 20-40 years age group. This is likely due to the number of students, clerical workers, scientists, and young housewives included in this group.

Refraction and Convergence Insufficiency

In approximately 50 per cent of our cases the patients were relieved of their discomfort when they wore proper glasses. In general, we followed the rule of slightly undercorrecting in cases of hyperopia, giving fairly full correction in cases of myopia, and encouraging the use of bifocals when they were indicated. Our statistics did not bear out the often-stated fact that convergence insufficiency is most frequently associated with uncorrected myopia. An equal number of cases (45 per cent) required hyperopic and myopic astigmatic corrections.

In 16 symptomatic cases in which a refraction determined that either no glasses or glasses with a small minus correction were needed, the final decision was based on the orthoptic evaluation and the effect which the minus correction had in improving the amplitudes on the synoptophore. Fifty per cent of these cases remained asymptomatic when the patient was treated only with glasses. In the other 50 per cent, the patients were given a few orthoptic treatments and glasses with a weak minus correction. All of these patients are now comfortable, as far as we know.

Treatment

All orthoptists and ophthalmologists, we feel sure, are familiar with the routine therapy used for convergence insufficiency. We have found this to be quite satisfactory for all of our cases which need therapy. The usual routine consists of (1) proximation exercises; (2) prism base-out exercises for near and distance; (3) physiological diplopia, framing, bar reading; (4) synoptophore; (5) stereoscope (at home); and (6) ortho-fusor, which is usually enjoyed as a grand finale.

SUMMARY

The following points have been discussed:

1. A complete muscle-balance test is of importance in a routine eye examination.
2. The frequency of convergence insufficiency is revealed when a complete muscle-balance test is done.
3. Normally, convergence exceeds divergence, but the reverse situation is usually associated with convergence insufficiency.
4. Proper refraction of the patient with convergence insufficiency is frequently the only necessary treatment, but many cases do require glasses and treatment, or treatment alone.
5. Constant use of eyes for close work, especially in certain occupations, plays a definite part in producing symptoms in patients with convergence insufficiency.
6. Standard accepted orthoptic treatment is adequate for the recovery and comfort of the cooperative patient.

ACCOMMODATIVE ESOTROPIA

ALEATHA J. TIBBS, O.T.
ATLANTA, GEORGIA

THIS morning Dr. Tait mentioned that a patient with an accommodative esotropia often had an emotional problem. I wholeheartedly agree with him. I find these children to be highstrung usually, and quite often it takes time to get them settled down and feeling accepted before good orthoptic training can be started. Consequently, to me it seems of great importance to build a good relationship between the child, the parent and the orthoptist.

When a patient comes to your office you should have from the doctor the child's refractive error, his vision in each eye, his punctum proximum, his basic esophoria, if any, and, if possible, his amplitude or relative fusional divergence.

Since Dr. Cooper has gone into the physiology, I should like to discuss the practical side and to go through a complete examination of an accommodative estrope.

VISION IN EACH EYE

Punctum Proximum

The punctum proximum denotes the power of absolute, not relative, accommodation and is measured monocularly. While one eye is covered, a 20/30 symbol is held close to the other eye and is moved out slowly until the child can identify it. If the punctum proximum is remote, the patient has greater difficulty on near work.

Amplitude of Relative Fusional Divergence

The amplitude of relative fusional divergence must not be confused with the amplitude of relative accommodation. The amplitude of relative accommodation is determined by (1) superimposing plus lenses while the patient maintains a fixed convergence until he has blurred single binocular vision; then (2) superimposing minus lenses until either blurred single binocular vision or esotropia results. The strength of plus lenses represents the negative relative accommodation, and the strength of minus lenses represents the positive relative accommodation; the total strength of plus and of minus lenses represents the amplitude of relative accommodation.

Bifoveal fixation is made possible through the vergence reflex. Clear vision and bifoveal fixation are possible by accommodation and convergence. We know that one diopter of accommodation reflexly calls forth approximately one meter angle of convergence. Since few of us have emmetropic eyes, this accommodation-convergence association must become dissociated in order for us to maintain straight eyes with clear vision. It is through relative fusional divergence, which is that amount of divergence which overcomes excessive convergence brought about by excessive accommodation, that we are able to maintain straight eyes with clear vision. In other words, relative fusional divergence is "putting on the brakes" to maintain proper alignment along with clear vision.

In working with the accommodative esotrope we are attempting to increase the amplitude of relative fusional divergence. The accommodative esotrope has no breaking power and has to make one of two choices, either bifoveal fixation with blurred vision or esotropia with clear vision. The amplitude of relative fusional

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divergence can be measured in three ways, always keeping the accommodation controlled:

1. Major amblyoscope: Use foveal targets and set the arms at zero. Add minus lenses of equal power until clear bifoveal vision is no longer possible, then back up one-half diopter and establish divergence to the end point of diplopia or of blurred vision.

2. Rotary prism: Use a reduced Snellen near-vision chart. Add minus lenses to the break point, then back up one-half diopter and establish divergence to the end point of blurred vision or diplopia.

3. Prism diopters: To me, the best and handiest way is to (a) neutralize the refractive error; (b) have a fixed degree of convergence, usually 3 meter angles of convergence; (c) control accommodation on a 20/30 symbol; and (d) superimpose minus lenses of equal power. Do a cover-uncover test to determine whether single binocular vision is present with accommodation. Add minus lenses, increasing one-half diopter at a time, and check presence of single binocular vision with accommodation each time. To overcome the excessive convergence associated with excessive accommodation to see clearly, it is necessary to apply relative fusional divergence if clear vision and bifoveal fixation are to be maintained. When the amplitude of relative fusional divergence can no longer overcome the excessive convergence, accommodative esotropia results. Back up one-half diopter to the point of the outer limit of amplitude of relative fusional divergence at which the patient maintains clear single binocular vision and make a prism-and-alternate-cover measurement. This is roughly a measure of the total amplitude.

Deviation

The patient with accommodative esotropia has straight eyes and clear vision with glasses and has esotropia with clear vision without glasses. The actual prism-and-alternate-cover measurement may vary without correction, so that, in terms of "how many diopters," is not too important. In diagnosing accommodative esotropia, it is extremely important to measure the basic esophoria and to determine the accommodation-convergence ratio.

Basic esophoria is measured by prism and alternate cover while the patient fixates a symbol at 20 feet in an unaccommodated state. The refractive error is neutralized while the patient reads a small symbol at 20 feet. If you do not have the cycloplegic refraction, add plus lenses to the blur point, then back up one-half diopter and do a prism-and-alternate-cover measurement. This is a mechanical alignment and cannot be overcome by nonsurgical treatment.

Accommodation-convergence ratio. If the prism-and-cover measurement is the same for distance and near, the accommodation-convergence ratio is normal. If the measurement is greater at near or at distance, the accommodation-convergence ratio is abnormal. The usual abnormal accommodation-convergence ratio in the accommodative esotrope is one in which the deviation for near is greater than for distance. This type requires bifocal lenses to get clear bifoveal vision for reading.

TREATMENT

In treating accommodative esotropia, the aim is to afford the patient comfortable single clear binocular vision without glasses. If the refractive error is too high, as much as S+400 or more, care must be taken not to push the patient beyond his limits. I consider an S+200 ideal. Beyond that may take two series of exercises, perhaps several months apart. If the patient has symptoms either with a weaker glass or without glasses, it would be unfair to insist on his going without the needed correction to be comfortable.

The usual sequence of treatment comprises (1) treatment of amblyopia, (2) overcoming suppression, and (3) developing amplitude of relative fusional divergence.

Treatment of Amblyopia

Usually amblyopia is not severe; however, if it is present, the better eye should be occluded until vision is brought up to the best possible level in each eye. A well organized program, such as stringing beads, sewing, and all sorts of games which require good vision, should be given at home for several weeks. If a child is about eight years of age, equal vision may be difficult to maintain. I believe a patch, as inconspicuous as possible, should be used. Often people are inclined to forget how a child who has to wear a patch and take all the remarks from other children may feel. If the child wears glasses, and is only moderately amblyopic, permafilm may be used; it is hardly noticeable, and the child usually does not object. I never force a child over 6 years old to wear a patch. In my experience, children have cooperated wonderfully when they understood the problem and were given a choice in deciding on the patch. You can draw a picture of the two eyes and call the foveas the bosses and the extraretinal elements little men who work for them. Children love to learn the meanings of words such as fuse and suppression. When the child understands that his eyes are not fusing and that one "boss" (fovea) is not working at all, he is quite willing to do something about it. In six years I have had only one child old enough to reason who would not wear the patch; that child had a mother who did not understand enough to cooperate intelligently.

Overcoming Suppression

There are many ways to overcome foveal suppression. On the major amblyoscope, the patient can fixate a foveal dot or any foveal target with the suppressing eye. This picture is held stationary while the dominant eye fixates a circle into which the dot will barely fit. The child is instructed to keep constant fixation on the dot while he moves the circle so that the dot is seen to the right of it and then to the left of it. At first the dot will jump up or down or all around; but as the suppression breaks, he will be able to superimpose the dot in the circle. When superimposition is achieved, place a foveal fusion target in to see of he is able to fuse. This same exercise can be carried out at home on the tracograph, which is described in Mary Kramer's new book.

The whole treatment is based upon good diplopia. This exercise is carried on throughout the course of treatment. The patient must be taught the difference between straight eyes and crossed eyes. If, with correction, the eyes are straight for near, the correction is removed; if the patient wears bifocals, he looks through the top segment while he fixates a target 13 inches away. The reason for this is that the images will appear to be closer together when he looks through the top segment than they are without correction, thus making it easier for him to recognize double vision. A red filter is then placed over the squinting eye. As the patient fixates the white light with the dominant eye, the eye behind the red filter is covered and uncovered; the red light then begins to blink on and off. As the operation slows down, the patient should appreciate homonymous diplopia. While he continues to fixate the white light, the red filter is moved on and off until he can hold diplopia without the red filter. Repeat this same procedure while he accommodates without glasses at 20 feet on a Snellen chart and on symbols at near. It is important for him to recognize diplopia with either eye fixating, for sometimes he may begin to suppress the dominant eye when the usually squinting eye is straight. I believe it is important to teach the child conscious alternation until he has good diplopia; but

I disagree with the theory that one should intentionally create an alternator. It is very difficult to teach good secure fusion to an alternator.

At this period in the training, the patient must recognize that clear vision and diplopia mean crossed eyes and blurred single vision means straight eyes. If he has difficulty in learning to blur his vision to straighten, hold plus-three spheres in front of his eyes while he fixates a symbol 13 inches away. If he does not cross his eyes when the spheres are moved off and on a few times, he will have blurred vision. He must learn to cross his eyes and to straighten them voluntarily. I ask my patients to look at a chart at distance and practice crossing, then read one line on the chart on the left and one line on the chart on the right before straightening to fuse the charts. They are expected to practice the same exercise at near.

Often, because of a stubborn foveal suppression, performance may be poor. If the eyes are straight with glasses, but there is still foveal suppression, instead of using a patch, I use a red filter over the dominant eye. The patient wears it constantly. He does his school work with a red pencil, and for home exercises he strings seed beads in all the pastel colors, sews with pastel shades of thread, and traces and colors with the same shades. Since the pencil, and the shapes of the beads and thread are seen with both eyes and the color is seen only with the suppressing eye, the red filter teaches fusion and vision. To get the child to accept wearing the red filter you can show him a magic trick by having him write his name with a red pencil and then point out how it disappears when he looks at it through the filter. We think of it as playing a joke on that lazy boss who doesn't want to do his share. Give him an extra red filter so that he can show his friends the magic trick. One teacher whom I know passed the red pencil and filter around the school room to show the trick to all the other children. You might suggest to the mother that she mention this idea when she talks to the child's teacher.

Developing Amplitude of Relative Fusional Divergence

Physiological diplopia is taught in many ways. Framing is the simplest one and leads to the more difficult ones. It is excellent in helping the patient to secure straight eyes after he has learned to straighten and cross without glasses. If foveal suppression exists, I have the child practice framing balls from the size of a nickel down to the tiniest dot with glasses. The Soft-Lite Lens picture card is also very good for framing, and it is a forerunner of bar reading. Bar reading is a good exercise, but it is not as effective in developing amplitude of relative fusional divergence as the Walraven Bar Separator.

I do not use the Walraven Separator as Miss Walraven does, or for the purpose for which she developed it. I use only two cards which come with the instrument, the two with the balls on them, as starters. I find that eyes may cross just enough on the A card to superimpose two of them, consequently the child may not appreciate diplopia. If you use that card, it is a good idea to draw a red line through the center of the card so that the child has double vision when the eyes cross.

I find that the Walraven Separator is invaluable in developing amplitude of relative fusional divergence; however, this is the most difficult exercise to master. People with incomitant squints or anisometropia cannot fuse away from the very center of a card.

The child and mother must have a good concept of physiological diplopia from the divider. The patient must understand the difference in seeing between the divider and through the divider. To teach him this concept, place a card between his eyes against the bridge of his nose and hold

your finger about thirteen inches away. While he fixates on your finger, move it from left to right and ask him to report when he sees it between the cards while it is straight in front of his nose, and when he sees the finger through the card as you move it to the left or to the right.

Place the card with the big red ball in the separator first and ask the child how many balls he sees. If he sees two balls, the eyes are crossed and the child has diplopia. If he sees one ball, he must recognize whether it is between the dividers, which indicates fusion, or whether it is on one side of the divider, which indicates suppression. When he is able to fuse the big ball, insert the second card with one small red ball and two small green balls. If he fuses correctly, he will see the red one between the dividers and the two green ones through the dividers. Have him practice looking from one green ball to the other green ball while he tries to keep the red ball fused by holding his eyes straight.

If the child has difficulty fusing the first two cards above, you can loosen the back and recess it a little. When he can straighten his eyes with physiological diplopia, advance the back and replace it in the catch. Also, to help him fuse, ask him to pretend that the card is a window through which he is looking far away. This elicits some divergence. After he is able to maintain fusion on the balls, he is ready to begin reading. We have a card with letters graduating from large to small sizes. To start with, wearing whatever correction is necessary to make it possible, the patient must clear the very large print which he sees between the divider. In order to maintain straight eyes and clear vision as he reads to the right side, where the divider is acting as a cover over the left eye, he must exert relative fusional divergence to prevent the left eye from turning in. The same is true when he looks to the left. In the beginning, this is most difficult; consequently, I have devised a little method which makes it easier. I ask the child to point to the letter which he sees in the middle between the dividers and read it aloud. Then I ask him to point to the letters as he reads from left to right and from right to left, adding only one letter on each trip back and forth. This takes him into fusion between the dividers where bifoveal fixation is present, and out of bifoveal fixation while he reads on the right and on the left sides. Each time he goes through the center, he obtains reinforcement and gradually he can maintain straight eyes on the whole line. The procedure is repeated on the line of smaller print below and so on until he can maintain clear single binocular vision on 20/30 print.

This is the first goal, and we have now reached the point at which we may begin reducing the strength of his glasses. Superimpose minus .50 spheres over his glasses and check his single binocular vision while he accommodates. If he is able to hold the eyes straight with clear vision on 20/30 print, he should wear minus .50 spheres fitover for constant wear, and continue the home exercises on the separator, repeating the above procedure of clearing from the large to the small print with his weaker glasses. When he has accomplished clear single binocular vision with the minus .50 spheres, superimpose minus 1.00 spheres and repeat the same procedure, and so on and on until he is without glasses and can hold the eyes straight with clear vision. For those children who cannot master the divider, you will have to settle on using bar reading as a substitute. Use the same technique of pointing, however.

Now, it isn't enough only that the child is able to hold the eyes straight without his glasses. He must have some reserve to fall back on in case of fatigue or illness. He should continue practice with the divider without his regular glasses and with minus .50, minus 1.00 and minus 1.50 spheres until he can clear his single binocular vision without difficulty.

It is interesting to compare the measurement of amplitude of relative fusional divergence at the end to that before his training began. I should like to comment on an observation which we have made in our office, that if the amplitude of relative fusional divergence does not increase consistently with the amplitude of relative accommodation, the progress toward comfortable single binocular vision is not as good. If both increase consistently, I do not fear that the result will not be permanent.

If there is a high basic esophoria, it may prevent comfortable single binocular vision without symptoms, and some surgery may be necessary. In determining the full amplitude of relative fusional divergence, remember that the patient is overcoming also any basic esophoria which may be present.

Working with accommodative esotropias is very gratifying to all concerned. With each new fitover the child feels that he has reached another rung on the ladder of success, and in the end we are all relieved that the great transaction is done at last. The usual series of exercises takes from six to twelve weeks, depending on the refractive error. I see such patients two or three times a week for eight or nine times, then once a week two or three times, then gradually taper off. After the patient is dismissed, he should be rechecked monthly two or three times, and then every three months for the first year.

PRACTICAL EXPERIENCE WITH INTERMITTENT EXOTROPIAS

BARBARA SIMMONS
WOLVERHAMPTON, ENGLAND

IN talking about intermittent exotropias, I have included all cases which for distance fixation show an intermittent or constant divergent deviation of the visual axes, and which for near fixation demonstrate a latent divergent deviation or, occasionally, an intermittent divergence. There has been some controversy over the terminology applied to these cases, which was very well covered in papers by Dr. Costenbader and Dr. Jampolsky. To avoid any confusion, I want to define the type of cases I am dealing with in this talk. I have not included any cases of pure exophoria, which I define as a strictly latent divergence of the visual axes at any distance of fixation, the exophoria being demonstrable only by suspension of fusion by artifice, using the Maddox rod or occluder. Neither have I included any case of constant exotropia. However, I have not distinguished between the divergence excess type and the convergence weakness type of intermittent exotropia. Divergence excess as a diagnosis is somewhat misleading, since there are different interpretations. Duke-Elder defines it as a condition in which the visual axes are parallel for near fixation and divergent for distance fixation. Other authors state that divergence excess implies a divergence of the visual axes which is greater for distance than for near fixation.

In the small series of cases which I have collected, the majority had a deviation greater for distance than for near fixation. Seven out of 27 cases had a greater divergent measurement for near than for distance fixation, by the prism and cover test. None of the cases seen was the so-called true divergence excess type, that is, orthophoric at near and divergent at distant.

My interest in intermittent exotropias was stimulated by my own impression, as well as that of other English orthoptists working in the States, that there the percentage of intermittent exotropias was larger than the percentage found in England. This was also the impression gained by Miss Holt when she worked for two years in Australia. In view of these impressions, I checked through the orthoptic files of the Bayshore and Levittown offices; of the total of 452 muscle cases seen, 60.4 per cent were convergent squints, and 20 per cent were divergent squints. This is, I believe, a fairly high proportion.

I have selected 27 of the cases of intermittent exotropia with which I have worked in the 15 months I have been here.

In evaluating the histories of the 27 cases, I found that occasionally the divergence was noted from a very early age, in some cases from birth. This was also found by Dr. Costenbader, who in his series reported 475 out of 528 intermittent exotropias with an average age at onset of 14 months, 204 being congenital. I also found the average age at onset in this small series to be 14 months, but I should mention that the exact age at onset was given in only 18 cases. Four of the cases were said to date from birth.

The etiology of these cases remains obscure. Little can be learned from the his-

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tories. In the literature many theories are offered, including mechanical causes, located in the extraocular muscles, such as anomalous muscle insertions and muscle bands. The most common of these findings seems to be a muscular or fibrous band running from the lateral rectus to the inferior oblique. Another frequently quoted cause is an exaggerated divergent position of rest of the orbital axes. Anomalous innervations are frequently cited as factors, and we are now learning more about them because of the work of Dr. Adler and Dr. Breinan. Refractive errors have been shown to play little part in the etiology of these squints, as the majority of intermittent exotropias display a hyperopia relative to the age at incidence. Of the 27 cases under review, only 4 had myopia and/or myopic astigmatism. In these 4 cases, correction of the refractive error did not effect a cure and surgery was necessary.

Although the histories gave no help in determining the cause of the squint, certain common characteristics were observed. The most common observation by the parents was that the child either shut one eye or covered one eye, particularly in bright sunlight. Dr. Costenbader has reported on this symptom and calls it visual confusion. He supposed that this confusion arose because the temporal retina (that used by the divergent eye) is less easily subjected to light and form suppression than is the nasal area of the retina; therefore, closing one eye was an effective mechanism to overcome diplopia if suppression could not be acquired.

Another characteristic which is repeatedly reported by the parents is that the eye diverges mostly when the child is tired or day dreaming, and that this divergence is more often noted when the child is ill. This characteristic is readily explained on the basis of neuromuscular fatigue; that is, under adverse conditions the stimulus or desire for binocular single vision is inadequate, and under such conditions control of the deviation is not maintained.

Yet another characteristic is the absence of symptoms. This is not surprising, since the condition is one which starts in early childhood at a time when the binocular reflexes are insufficiently grounded, and the temporary loss of binocular vision fails to make any serious impression on the child. The child is too young to appreciate the rewards of binocular single vision, and the demands for accurate visual judgments are very limited. In most cases the child is not sufficiently aware to describe the double vision, should there actually be any. Later on, in adolescence and adulthood, when the visual demands are great, unless an effective suppression mechanism has been developed for the occasions of intermittent divergence, symptoms are experienced. The symptoms are usually quite severe headaches, occasional diplopia, blurring of vision, and a generalized sensation of eye strain.

Until such time as our knowledge of the etiology of intermittent exotropia is more exact, the treatment of these cases will continue to be empirical, the choice of treatment lying in optical, orthoptic or surgical correction according to the individual findings. As yet there seems to be no lasting cure for all cases. Orthoptic training has been shown to establish a voluntary control of the deviation, and surgery can lessen the degree of divergence. But all too often after such treatment, the intermittent divergence is still noted. It is admitted that this occurs much less frequently than before surgery, and to a less degree, but the fact remains that some of the deviation usually persists.

The treatment employed by us in the correction of intermittent exotropias has, I believe, been routine: refraction and correction of any refractive error which could cause reduction in visual acuity, such as errors of myopia or myopic astigmatism; no correction was given for the small degrees of hyperopia found. This was followed by preoperative orthoptic treatment. On the first visit the patient, after

being examined by the doctor, was screened by the orthoptist, who assessed the vision, the degree of deviation, and the state of binocular vision. Obviously the information gained on the first visit varies according to the age and cooperation of the patient. The next step was refraction under atropine, which was done routinely in all cases. Glasses were prescribed in the 4 cases already mentioned in which there was myopia; in all other cases the refractive error was insufficient to warrant a correcting lens. In most of the cases it was possible to gain sufficient information in the first two visits to determine the course of treatment. The plan for treatment was then explained to the parents, from whom cooperation is essential if treatment is to be effective.

In all 27 cases, surgery was decided upon from the outset. It was explained to the parents that glasses could not correct the condition, and that exercises alone could only, at the best, effect control of the deviation, which would put the child under considerable strain. On the other hand, surgery combined with exercise would reduce the deviation so that there would be the minimal amount of divergence to control in order to achieve binocular single vision, and this would not involve any conscious effort on the part of the child.

Surgery was considered necessary in these cases, since the aim was to eliminate, as far as possible, the divergent deviation, in order to obtain (1) improvement of binocular function, thus ensuring constant use of binocular single vision; (2) prophylaxis, preventing the occurrence, later in life, of symptoms which may arise from the conscious or subconscious control of the deviation; and (3) cosmesis, since this condition is not considered a thing of beauty. Unfortunately, surgery does not appear to be a complete answer to the problem of curing these cases, since the majority of cases so treated have shown a persistent divergent deviation. However, it invariably reduces the degree of divergence so that more effective control can be established with orthoptic exercises. The cosmetic defect is considerably improved. The fact that in so many cases surgery cannot produce a complete cure, would indicate again the innervational factor in the etiology of these squints.

The criterion of success in these cases has to be based on measurements, since the majority of these cases are asymptomatic and have binocular vision at the outset. Many, too, by virtue of preoperative orthoptic training, have been converted into exophoria prior to surgery. It may be questioned whether in those cases which were converted to an exophoric status, surgery was justified. We believe that it was justified; unless the actual degree of deviation is considerably reduced, which is only possible by surgery, voluntary control of the deviation with a good near point of convergence may only result in symptoms later on. This was seen in one of the 27 cases.

A married woman, aged 26, with a family, had an intermittent exotropia dating from childhood. She had had exercises to control the squint. At the time we first saw her, she was complaining of severe frontal and occipital headaches. The prism cover test showed an exophoria, becoming exotropia, of 25 prism diopters for distance, and 35 prism diopters for near. We did the prolonged occlusion test as a diagnostic procedure to ascertain whether her symptoms, which were of relatively recent origin, were related to the ocular imbalance. The test demonstrated that this was the case, since the headaches were relieved when the patch was worn. Surgery, therefore, was decided on. Bilateral lateral rectus recessions were done, 5 to 6 mm. The patient was given postoperative orthoptic treatment and homework exercises, and the near point of convergence was reduced from 15 cm. to 7 cm. Full binocular single vision was attained; at the time of the patient's last visit it measured 2 prism diopters of exophoria for distance fixation, and 8 prism diopters of exophoria at near. She was told to report back only if symptoms recurred.

I have reported this case here because it demonstrates the fact that symptoms

can and do occur in those cases of intermittent exotropia which have received early orthoptic treatment.

The optimum time for surgery is still debatable. It will vary according to individual considerations: age, cooperation, and physical and mental health of the patient, and economic status. Aside from these considerations, the choice is between surgery at an early age, when the child is first brought to the ophthalmologist for treatment, and surgery as late as possible in childhood; and in some instances only if symptoms occur or there is a marked cosmetic defect. Surgery may be delayed to allow for maximum growth of the face and orbits, ocular muscles and adnexa. It is said that with growth there is a tendency towards a divergence of the visual axes. The factors influencing a tendency towards divergence are (1) innervational, due either to a decrease in convergence impulses or to a convergence weakness or insufficiency which usually is a secondary development in cases of untreated intermittent exotropias; and (2) anatomical, due to a condition of exophthalmos which may arise if the development of the face and of the orbital contents are not coordinated and which disturbs the angle between the eyeballs at rest. Accordingly, in such cases the action of the oblique muscles as abductors is increased with the result that the resting position of the eyes becomes one of considerable divergence, as stated by Keith Lyle. However, in normal development there is no such increase in divergence; in actual fact, the degree of divergence of the orbital axes is decreased by 5 degrees from birth to adulthood.

In favor of early operation are the following factors: (1) The most important factor is the aim of restoring constant parallelism of the visual axes as soon as possible. In view of our knowledge of the development of the binocular reflexes, it seems important to prevent any deviation of the visual axes, since repetition of such deviations results in the conditioning of abnormal reflexes. Although, in the cases of intermittent exotropias, binocular vision is developing normally when the visual axes are parallel, anomalous sensory correspondences are developing when the visual axes are divergent. The longer this condition is allowed to exist, the more difficult it becomes to correct. Most authorities are agreed on early operation in the case of constant deviations, since this is the only chance of obtaining a functional result. The same agreement does not exist when the deviation is intermittent in character, since it is said that there is not so much to be gained. We do not agree with this, since any delay results in the acquisition of abnormal sensory reflexes, which in time become unconditioned. (2) The psychological factor should also be considered. A young child, generally speaking, does not know fear and is not likely to worry or to be concerned about an operation; this is not so with the older child. Moreover, it is preferable to have the squint corrected before the child's school friends make him conscious of his cosmetic defect.

In advocating early surgery, it is suggested that the operation not be done before the child is 4 years old, since it is important that he should be able to cooperate sufficiently to permit orthoptic treatment, preferably before surgery and certainly after surgery. It is for this reason that no definite optimum time can be stated for surgery, for the ability to cooperate varies with each child.

The aim of preoperative orthoptic treatment is to break down the abnormal sensory reactions of the divergent deviation. In most cases this is suppression of varying intensities, preventing diplopia and normal retinal correspondence. In the cases under review, none of the children demonstrated a definite abnormal retinal correspondence at the divergent angle. However, it was found in 2 adult cases, which supports the theory that abnormal retinal correspondence is more likely to be found in cases of long standing. The im-

portance of preoperative orthoptic training rests on the fact that surgery does not always result in perfect orthophoria. Therefore, any residual deviation results in the continuance of the abnormal sensory pattern. Thus, although the cosmetic defect is lessened, the binocular function is materially unchanged. In this series, all but 5 patients received preoperative orthoptic treatment. Three of these patients were older children who could effect a voluntary recovery at distance fixation, one was the adult already mentioned, and the fifth was a child too young to treat. The average number of preoperative orthoptic treatments was four.

As already stated, the aim of the treatment was primarily to overcome pathological suppression, present when the divergent deviation was manifest. In most cases this was invariably the response at distance fixation, and in a few cases in which the deviation was intermittent at near fixation it was also present. The methods used were total occlusion if the vision was deficient in the usually deviating eye. However, in most cases it was only necessary to use intermittent patching, since none of the cases demonstrated amblyopia of any severity. For intermittent patching, the mother was instructed to put the patch on the child for at least one hour a day, during which time the child was to be encouraged to do some type of close work. Tracings are an excellent way of trying to overcome suppression; however, the most popular occupation, needless to say, was watching television. In the office visits, the child was given exercises to make him aware of diplopia. The standard methods were used: red and green diplopia goggles and fixation light, exercises on the troposcope. The most valuable of the exercises were those using fusion slides. In stimulating fusion, particularly at the divergent angle, one overcomes suppression by making the patient aware of both controls and intent on keeping both controls as the pictures diverge further. Convergence was stimulated only in those cases in which there was a marked convergence weakness; in such cases the emphasis was on making the patient aware of the point at which convergence failed, i.e., on making him aware of the diplopic images. We do not consider it advisable to concentrate preoperatively on stimulating convergence, for this may produce a spasm of convergence postoperatively.

In a few of the cases, spontaneous diplopia was appreciated from the outset of treatment, and it was obtained in 15 cases with treatment. It was not obtained preoperatively in 6 cases. In 6 other cases the records did not disclose whether diplopia was present. The fact that the majority of these cases obtained preoperative diplopia in as few as four orthoptic treatments was very interesting. I was surprised, even though I realized that homework exercises were being carried on concurrently. It had always been my impression, from approximately five years of orthoptic experience in England, that intermittent exotropias displayed a dense type of suppression which was very difficult to overcome, and in many cases seemed impossible. The different results I was obtaining here, using similar methods, asked for an explanation. I discarded the explanation that I was seeing the cases of intermittent exotropias here at an earlier age, so that the suppression was still conditional and not so firmly grounded, for the data indicated that the average age of the children I saw in England was about the same as that of the children here. The only difference I found was in the temperament, behavior, and upbringing of the American child as compared to these factors in the English child. It has been shown by Pavlov's experiments on dogs that the effects of stimuli were different according to whether the animal belonged to the excitable or inhibitable type. Likewise, in human beings the reaction to a certain stimulus varies. The phlegmatic or stupid types, and hysterical types are apt to show profound

obligatory retinal suppression in contrast to the introspective or neurasthenic types, the latter being more docile and better able to tolerate diplopia. Perhaps some correlation may be drawn from this. It is amusing to speculate and interesting to note that this difference in types of retinal suppression found in these cases of intermittent exotropias was made not only by myself but also by other English orthoptists working in the States.

At each treatment a measurement of distance and near deviation was recorded so that any variability in the degree of deviation could be seen. It was found in practically all cases that the degree of divergence was greater on the second or subsequent visits than it was when first measured. The reason for this is probably twofold. On the first visit the child is more tense, expectant, and perhaps apprehensive, and unconsciously more of the deviation is controlled; whereas, on the second visit he is more relaxed and less apprehensive, and the full deviation can be measured. Also, the aim of the treatment is towards overcoming suppression at the divergent angle, thus unmasking the full amount of divergence. Probably one of the best methods of obtaining the full degree of divergence for measurement prior to surgery is the prolonged occlusion test.

The choice of the surgical procedure in every case was made by the surgeon and based on the recorded measurements. The standard operation employed by Dr. Bussey and Dr. Flynn has been recession of the lateral rectus, usually a bilateral procedure, depending on the degree of divergence. Bilateral rectus recessions were performed in all but two cases: in one there was a single rectus recession which proved to be insufficient and required further surgery; in the other there was a recession of the lateral rectus combined with a medial rectus resection on the same eye. The amount of recession varied from 2.5 to 6 mm., again depending on the degree of deviation to be corrected. In all but 3 cases the divergence was greatly reduced, although in no case was there orthophoria for both distance and near. Second procedures were necessary in these 3 cases: in one there remains divergence; and in the other two there was overcorrection, and retroplacement of the lateral rectus causing the secondary convergence was done. These two cases showed a definite limitation of abduction due to surgical overcorrection with resultant constant homonymous diplopia. After the second procedure, in one case there remained an exophoria of 12 prism diopters and in the other there is an esophoria which still tends to vary in degree. In the latter case, according to the mother of the patient, the convergence varies with the physical and emotional condition of the child.. When she is tired, ill, or excited, the esophoria becomes esotropia with resultant diplopia. This does not occur under favorable conditions, and it is felt that the degree of esophoria will lessen with time. In 4 other cases the deviation postoperatively was esophoria, becoming intermittent esotropia at times for near fixation. Again, it is felt from the trend already seen that in time the degree of esophoria will lessen. This can only be determined by the passage of time and by routine checks. In five of the cases intermittent exotropia at distance was still present.

Immediately following surgery, orthoptic treatment was started. Again the average number of treatments was four, but this number varied somewhat according to the need for such treatment. In all the cases, excepting those rendered esophoric or esotropic by surgery, the exercises were based on stimulating convergence. If the divergence was still manifest for distance, emphasis was placed on keeping the diplopia and on securing binocular single vision by joining the images. If the diplopia had been suppressed, the patient was again made aware of it in order to try for a conscious control of the remaining deviation. In practically all cases,

homework exercises were instituted as being an important part of the treatment. When the mother was cooperative and interested, the child was found to make much better progress. We found the simplest exercises to be most effective. The one most generally employed was objective convergence. The child's interest was gained by sticking characters from his favorite comics on tongue depressors for use as fixation objects. The near point of convergence showed a definite improvement in almost all cases over that recorded on the first visit. Other exercises included prism convergence, given with the prism bar at 20 feet, increasing the fusional range of convergence on the troposcope; bar reading; the diploscope; and homework stereograms, if the child's ability permitted. All of the parents were pleased with the results obtained. A few still noted an occasional divergence but said that it was not as marked as it had been before surgery.

It is too early to be able to draw any definite conclusion from the results we have obtained. It will be interesting to observe these patients over the next few months and years to see what course their exotropias take. It will be disappointing if the divergence recurs to the original degree. However, it is felt that only when the exact nature and cause of these very interesting squints is completely understood, can a solution be found towards a lasting cure.

I had hoped to be able to compare the results from bilateral recessions of the lateral recti obtained here, with results from bilateral advancements of the medial recti. I have seen some of the results of the latter operation while working in England, and they have been consistently good. The first finding was one of overcorrection immediately following surgery. This lasted two or three weeks, with a gradual decrease in convergence to orthophoria, and in some cases to exophoria. I am sorry that because of lack of time and the ability to collect the information required, I have been unable to compare the two procedures.

In conclusion, I want to thank Dr. Bussey and Dr. Flynn for their permission to talk about their cases.

THE SURGERY OF ESOTROPIA

GLEN GREGORY GIBSON, M.D.
PHILADELPHIA, PENNSYLVANIA

OPHTHALMIC surgeons have placed their methods of surgical planning, for most conditions with which they have to deal, on a sound and rational basis. In contrast to this relatively satisfactory situation, methods of surgical planning in esotropia acceptable by scientific standards have not been established. The surgery of esotropia was, therefore, selected for presentation before this society in an effort to obtain the aid of orthoptists in the formulation of surgical planning which may be acceptable. There are many important causes and reasons which make it difficult to formulate surgical planning which is applicable to the variable situations encountered in esotropia.

Since there is no authoritative source of precise information in the literature where a surgeon may obtain a specific answer to a specific problem, he must place his principal reliance on empirical methods of planning. The surgeon is in the disadvantageous and uneviable position of being forced to operate on structures which are only secondarily impaired, rather than on those which are primarily at fault. Since esotropia is not an etiologic entity, the accumulation of significant statistics is almost impossible.

The classification of esotropia is not satisfactory. It is easy to ascribe improvement erroneously to one form of therapy when the true benefits were derived from some other source. For these and many other reasons, it is understandable why planning is difficult and why end results leave much to be desired. In our efforts to formulate a solution to this complex problem, we have relegated the mathematical and mechanical aspects of this problem to a secondary role. The type of operative procedure has been selected on the basis of an estimation of whether the binocular fixation reflex mechanism or the postural reflex mechanism will play the dominant role in the maintenance of the relative position of the visual axes postoperatively. The extent of the operation has been determined on the same basis.

If it seems probable that binocular fixation is potentially attainable, a plan which is essentially physiologic is employed. If it seems improbable that the binocular fixation reflex will be effective, and therefore reliance on the postural reflex system will be necessary, a plan which is anatomic in concept is used. The decision regarding which of these two mechanisms is likely to be operative is based on an estimate of the probable permanent impairment of the binocular fixation reflex mechanism sustained by the patient before operation.

In order to make a reasonably successful estimate of whether the "bifixation" reflex mechanism is likely to come to the surgeon's assistance, an understanding of normal and abnormal sensory development in childhood is very helpful. Normal sensory development occurs when the patient is free from organic or functional lesions which prevent normal sensory reflex traffic in the eyes and their connections in the central nervous system. This process requires about five or six years. During this period the sensory function is improving both in acuity and in permanency of the reflex function.

At the risk of oversimplification, and with the admission that the curve is derived from clinical impressions rather than specific measurement, this reflex develop-

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ment can be expressed graphically by a curve which starts near zero at birth and ascends to normalcy about the time the patient reaches the age of six years.

Subnormal sensory function results when this process is interrupted by deviation of the visual axes during the developmental period. Functional regression results more rapidly in the period represented by the first third of this curve, and less rapidly in that represented by the last third. The degree of functional impairment sustained by the patient is estimated by comparisons of the normal developmental curve with the most probable subnormal sensory functional development of the esotrope. This complex problem is simplified by a careful estimation of the clinical significance of three important time factors.

These time factors are the age at onset, the duration of the deviation, and age at operation. If the deviation was present at birth, or occurred during the child's first year, it is improbable that the controlling influence of "bifixation" will be effective postoperatively. If the duration of the deviation exceeds six months in the first third, a year to a year and a half in the second third, or longer than two or three years in the last third of the developmental period, permanent sensory impairment may be anticipated. If the deviation exists after the developmental period, permanent sensory impairment usually results. Exceptions to these principles occur when the deviation is intermittent or when "bifixation" is present in some field of fixation.

The crucial decision in operative planning is based on the favorability, or unfavorability, of these time factors, and the absence of definite organic lesions. The favorability of the time factors increases with greater age at onset, shorter duration of the esotropia, and greater length of time available after alignment for further development during the developmental period.

In view of this time factor, the orthoptist and the surgeon should make their plans from the outset with one dominant consideration in mind. This consideration is which one of the two possible reflex mechanisms will be operative. If the time factors are favorable, a conservative procedure is indicated; if they are not, a more radical operative approach is necessary. When the time factors are favorable, we have found that our best results are obtained by the use of the conservative and physiologic operative procedure of marginal myotomy. It is unnecessary to graduate the amount of operative correction because the same amount of operative procedure corrects all amounts of deviation up to 45 degrees, since the final position is brought about by the binocular reflexes. It may take one or two years before these reflexes are effective and stability of ocular position results.

This operation has been most successful when age at onset was relatively late, when duration of the esotropia was relatively short, and when the patient was between the ages of two and four years. It is contraindicated when sensory symmetry is absent, as in amblyopia. The patient should be an essential or developed alternator. It is in the determination of sensory function that the orthoptist plays her most important diagnostic role.

When the neuromuscular findings are asymmetrical and the time factors unfavorable, the more extensive procedures of recession and resection are employed. Since we cannot graduate the amount of surgical correction accurately in these less favorable cases, an estimation of the most probable number of millimeters of total operative correction is employed. For deviation of 10 to 20 degrees, 4 to 6 millimeters of total operative correction, usually divided equally between two muscles, is employed. Increasing amounts are used as the amount of deviation increases. The amount of correction must be increased or decreased from the average depending on

the dangers of undercorrection or overcorrection. Amblyopia, high hyperopia, and remote convergence near points are signals for slight undercorrection, in which case less than the usual amount of operative correction for the amount of deviation is employed. Contractures, long duration of the esotropia, and adult status of the patient are signals for increasing the amount of operative correction above the standard for the given amount of deviation.

Unfortunately, the accuracy of our operative techniques does not compare favorably with the accuracy of our methods of measuring the amount of deviation. The best which we can possibly do is to divide patients into four grades on the basis of the amount of deviation, and to graduate our amount of operative correction so that the minimal deviations get the minimum amount of surgery, and the maximal deviations the maximum amount of correction, scaling this amount up or down on the basis of the nature of the clinical findings which suggest that the principal risk is one of overcorrection or under correction.

This method of planning is superior to the purely empirical approach, but in no sense can we pretend that it is adequate or not subject to improvement. The reason that scientifically acceptable figures are almost impossible to obtain is that we are dealing with a problem which contains an enormous number of variables, making it difficult to say with confidence that any one of them is, or is not, of major importance. The essential task for those working in this field is to obtain controlled significant figures, which will make it possible to develop surgical planning on a rational basis.

SOME FACTORS IN THE DIAGNOSIS AND TREATMENT OF ACCOMMODATIVE CONVERGENCE EXCESS

EDWIN FORBES TAIT, M.D.
NORRISTOWN, PENNSYLVANIA

CONVERGENCE excess, ordinarily manifested as more or less esophoria at the near point, is a frequent problem in refraction work and a fertile source of asthenopia. Probably more discomfort and discontent with lens corrections result from excessive esophoria at the near point than from any other heterophoric condition. Control and correction of the condition depend upon understanding the reason for its existence in the individual case and the applying of suitable corrective or relieving measures. There are several possible causes for excessive near-point esophoria, and these can best be understood by a study of the stimulus-response mechanisms (reflexes) which are involved in each case.

It might, first of all, be well to eliminate from consideration certain causal factors such as (1) uncorrected hyperopia for distance; (2) first lens corrections for previously uncorrected myopia; (3) ciliary effort in early presbyopes; and (4) efforts to see at near after cycloplegic drugs have been instilled into the eyes. While these four groups are also involved in the reflex systems discussed in this paper, the amount of the esophoria at near resulting from any one of them is usually small and ordinarily is reduced to exophoria after suitable lens corrections. In these groups, however, there may be certain individuals who will present a considerable amount of near-point esophoria even after they have spent some time with an adequate lens correction, and these are included in the following discussion.

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One other group must be eliminated from consideration in this paper: that which presents a very considerable amount of esophoria for distance with less esophoria at the near point. In these cases, usually classified as instances of divergence insufficiency, the fundamental difficulty is the basic or tonic position of the extraocular muscles for distance, and the near-point esophoria represents the carrying over of that basic difficulty to the near point with the aid of a normal amount of accommodative convergence. The reasons for the variations in binocular balance in such cases, and in all others exhibiting exophoria at the near point, can be understood only by a knowledge of the way in which the vergence reflexes operate.

Many years ago, Duane[1] endeavored to correlate heterophoria found with fixation at far distance with that manifested at the near point. The amount and type of the heterophoria for each fixation distance was determined by the process of alternate occlusion and the use of prisms; that method is still universally used today, even though it is more time consuming than the subjective procedures presented later in this paper. Regardless of the method employed, Duane found it possible to classify practically all heterophoric cases in one or more well-known groups, those presenting (1) convergence insufficiency, (2) convergence excess, (3) divergence insufficiency, and (4) divergence excess. This system, however, useful as it has been, is descriptive only and does not in any way indicate the physiologic mechanism which is responsible for the dysfunction. For the latter purpose, a study of the stimulus sources which result in the motor innervation to the intraocular muscles is more useful.

During the half century which has elapsed since their initial study by Maddox,[2] these vergence reflexes have been slowly becoming understood, the basic bar to widespread understanding being a lack of appreciation by ophthalmologists of the reflex arc in general and of its application to ocular problems, and a failure to apply Sherrington's epoch-making work on the reciprocal innervation of opposing muscle systems to the oculorotatory muscles.

The modern physiologic viewpoint in this matter has been presented elsewhere at length,[3,6] but I shall here endeavor to sum it up shortly.

For normal and efficient binocular coordination, only two of the four possible vergence reflexes are absolutely essential. These are usually designated as the functional vergence reflexes; they consist of basic (tonic) vergence and of fusional vergence. The basic (tonic) vergence is that which determines the position of the visual axes in relation to each other when the only source of stimulation which results in ocular movement is that from the supranuclear tonic areas of the brain stem, uninfluenced by accommodation, fusion, proximity of the object fixed, or any general hypertonic or hypotonic condition of the muscles of the body.

It must be understood that for any of the vergence reflexes to produce smooth and precisely controlled ocular movements, efficient reciprocal innervation or inhibition of each of the twelve extraocular muscles is required. Movement can come only by a modification of this reciprocal innervational process, and as soon as the position is again fixed, the tone of the opposing muscles must manifestly be equal. Therefore, even when the eyes are directed to a distant point many degrees away from the eyes-front position, the extraocular muscles, because of this reciprocal process, must be exhibiting the same amount of tone, whether extended or contracted.

As far as the motor systems of the two eyes in binocular vision are concerned, the significant factors in movement and fixation are the stimuli which, through the proper reflex pathways, produce the movements and maintain the fixation.

On the basic (tonic) innervation, which has been previously discussed, there must be superimposed the effect of the stimuli which arise from sources other than the tonic areas of the cortex and brain stem. Efficient binocular vision depends upon that which we may call fusional vergence, which is the result of the functioning of certain retinal receptors, probably normal rods and cones, which are reflexly tied up with the extraocular muscles through many devious cortical and subcortical nervous pathways, most of which are unknown.

Fusional vergence is the motor response to stimuli which reflexly modify the basic tonic innervation to the extraocular muscles in the interest of single binocular vision, and which are initiated by the perimacular and extramacular fusional receptors. The fusional vergence reflex is that which normally compensates for the presence of a heterophoria at the point of fixation. One eye, usually the dominant eye, fixes the object of regard, and the retinal image on the peripheral retina of the other eye then stimulates the extramacular fusional receptors, which then modify the tonic reciprocal innervation of the muscles of the second eye so that it immediately turns in order to obtain, on its own macula, the same image as that in the fixing eye. This process, of course, is exceedingly rapid in a normally functioning pair of eyes and the individual is unaware that noncorrespondence has existed for a moment.

Absence of the fusional vergence reflex means heterotropia, regardless of the cosmetic appearance. Occasional intermittent absence of effective fusional vergence is the condition, familiar to us, in the individuals with intermittent exotropia, or in the much smaller number with intermittent esotropia.

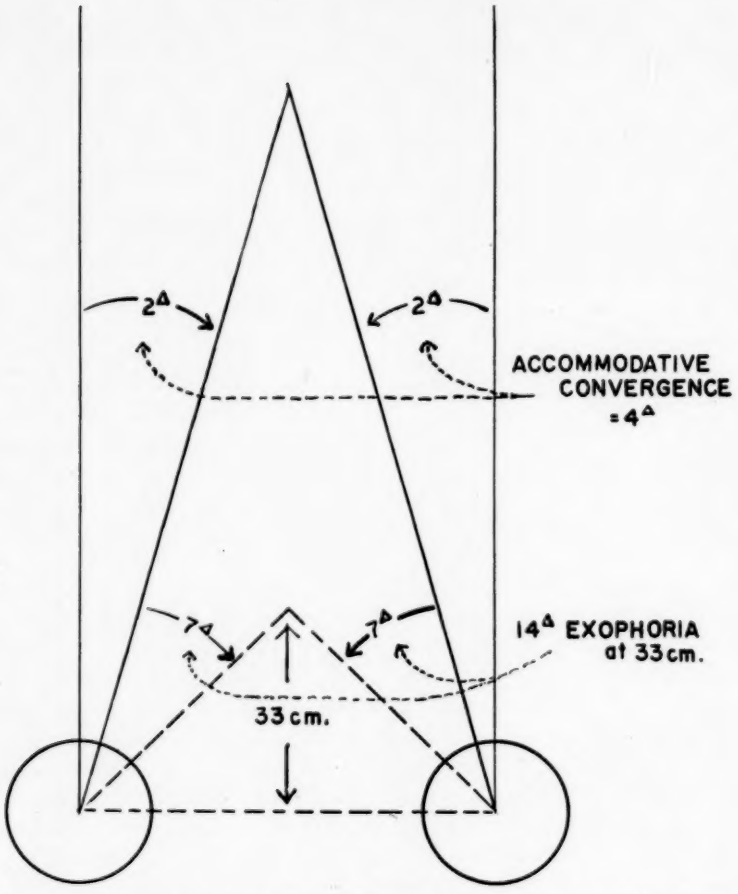

FIG. 1—Convergence Insufficiency. Orthophoria at 6 meters. 14△ Exophoria at 33 cm. Accommodative Convergence = 4△.

There are two other stimulus sources for vergence, both of which provide only convergence, namely, accommodation and proximity. Either of these may be the causal factor in convergence excess, but in almost all cases it is accommodative innervation which is the culprit.

Accommodative convergence is the modification produced in the distribution of reciprocal innervation to the extraocular muscles by the use of accommodation. The extent to which this reflex is operative determines the amount of exophoria or esophoria at near. Inasmuch as this reflex is not necessary for efficient ocular functioning, the amount of exophoria at the near point has no relation to comfort. Accommodative convergence is important only when it is excessive, creating an esophoria for near, for it then takes the place of the basic vergence reflex as that which must be modified by the fusional process.

Proximal convergence, on the other hand, is that which is stimulated by the nearness of objects in the absence of other effective stimuli. It is usually not greater than 3 or 4 prism diopters, although, in rare individuals, it may amount to as much as 30 prism diopters.

Accommodative convergence and its influence in producing lateral heterophoria

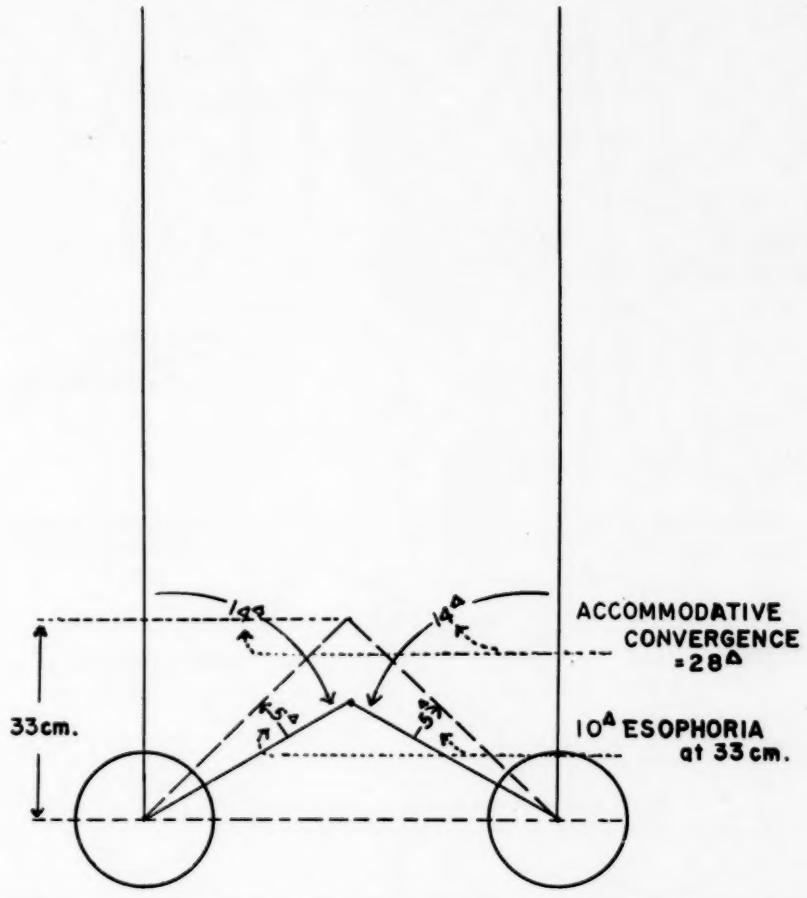

FIG. 2—Convergence Excess. Orthophoria at 6 meters. 10△ Esophoria at 33 cm. Accommodative Convergence = 28△.

at the near point in any individual can best be understood by analyzing each of the classes in the Duane-White schema, as presented above, and expressing them in terms of the vergence reflexes just discussed.

As will be seen in the accompanying diagrams, it is possible to have esophoria at near in any one of the Duane-White groups, except in convergence insufficiency (fig. 1). In that single group there is always exophoria at the near point because the accommodative convergence reflex in these individuals is not sufficient to provide enough convergence to produce esophoria for near.

Exophoria at near is the condition manifested by almost all comfortably corrected persons with good single binocular vision, and it must be considered as physiologically normal. Certainly the amount of exophoria has no relation to comfort at the near point, for it matters little to the patient whether it is small or great. It has been shown that the important factor in efficient binocular fixation at near is the amplitude of fusional vergence.

Figure 2 illustrates the effect of an excessive accommodative convergence in producing an esophoria at near when there is orthophoria or a slight amount of esophoria or exophoria for distance. This is Duane's "convergence excess." In practically all

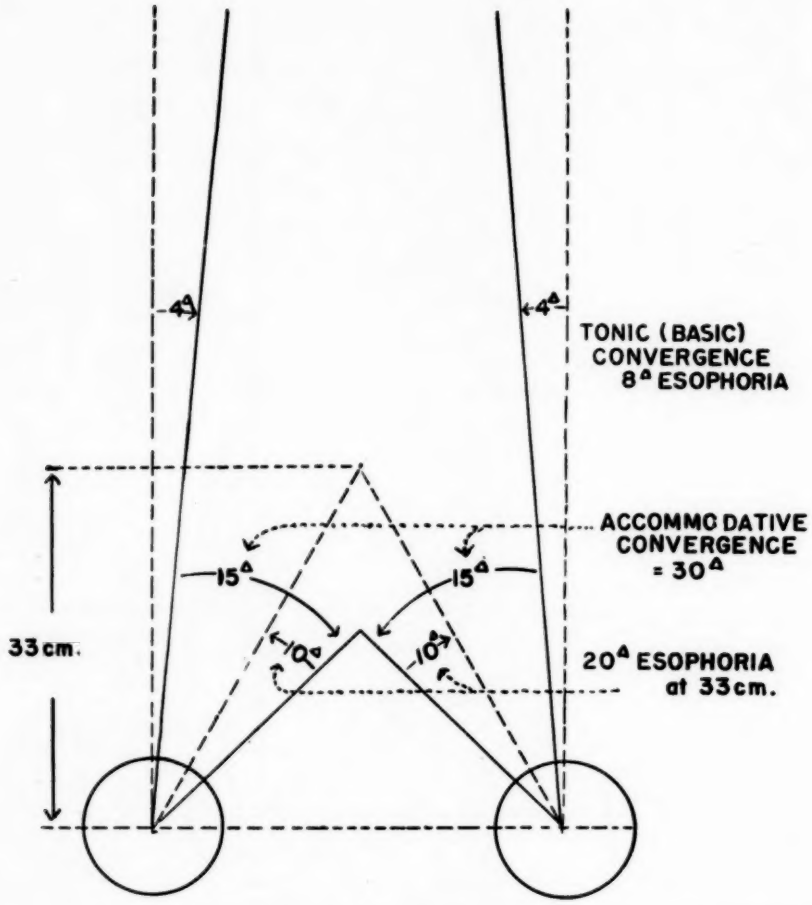

FIG. 3—Divergence Insufficiency with Excessive Accommodative Convergence. 8Δ Esophoria at 6 meters. 20Δ Esophoria at 33 cm. Accommodative Convergence = 30Δ.

cases, it can be shown that the association reflex responsible is that initiated by accommodative innervation. Addition of convex lenses while the patient is fixing at the near point and with fusion dissociated will reduce the esophoria and will usually cause the individual to become exophoric.

Divergence insufficiency and divergence excess are conditions which relate primarily to the position of the visual axes when fusion is dissociated and fixation is at distance. Under these circumstances, with all stimuli to convergence suppressed except that from the tonic areas of the brain stem, the individual with divergence insufficiency will have esophoria for distance, while the individual with divergence excess will be exophoric. The binocular balance at near, although influenced by the tonic vergence for distance, may or may not be esophoric, depending again upon the extent of the accommodative convergence reflex.

Divergence insufficiency with excessive accommodative convergence in an individual with 8 prism diopters of esophoria for distance fixation and 20 prism diopters of esophoria at 33 cm. is illustrated in figure 3. In this case it can be seen that the esophoria for near is dependent not only upon the tonic convergence for distance but also upon an excess of accommodative convergence, amounting as it does

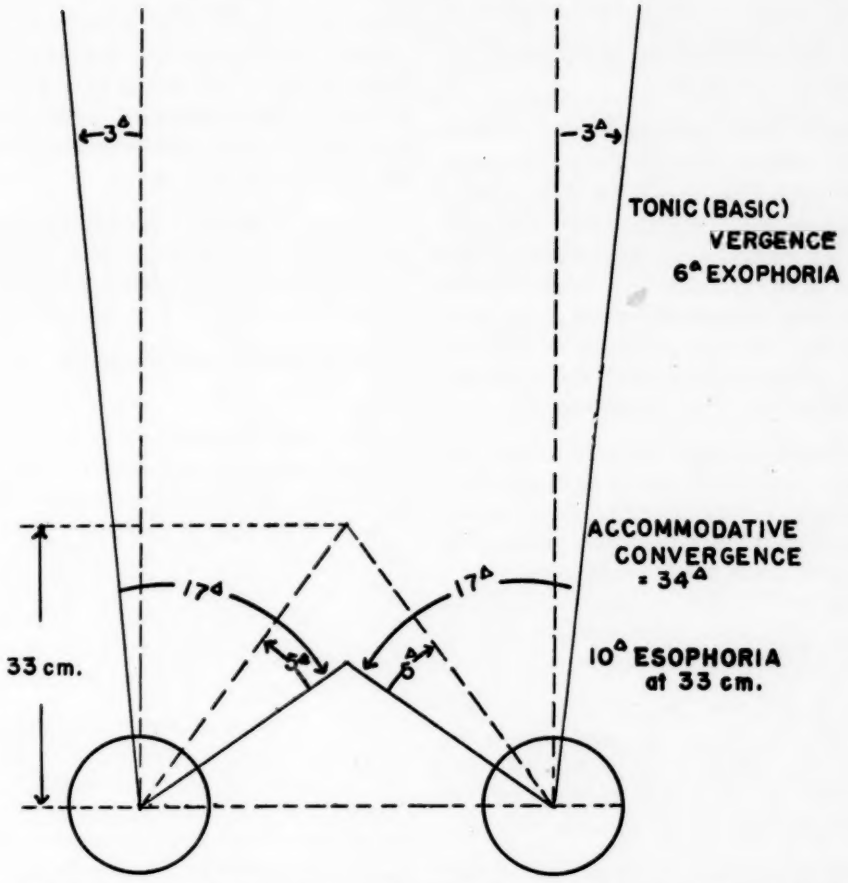

FIG. 4—Divergence Excess with Excessive Accommodative Convergence. 6Δ Exophoria at 6 meters. 10Δ Esophoria at 33 cm. Accommodative Convergence = 34Δ.

to 30 prism diopters instead of the usual and normal 12 prism diopters or less.

Divergence excess (fig. 4) involves a tonic divergence for distance, in this case 6 prism diopters of exophoria. Even with such distance divergence, it is still possible to have esophoria for near fixation, depending upon the amplitude of the accommodative convergence reflex. In the case illustrated, 10 prism diopters of esophoria at near is produced by 34 prism diopters of accommodative convergence.

In the above illustrations, it will be seen that esophoria at near is not peculiar to Duane's convergence excess group, but that it may also be present in divergence insufficiency and divergence excess, depending upon the amount of the accommodative convergence reflex.

In a very small percentage of individuals with esophoria at near, the condition seems to be caused by the proximal convergence reflex in which the stimulus is the psychic sense of nearness. These individuals can be recognized by the fact that the addition of convex lens power, when fixing at the near point under dissociation, will produce no lessening of the manifest esophoria.

All except a very few cases of convergence excess, therefore, are due to an overactive accommodative convergence reflex. The reflex picture in such individuals (figs.

2, 3, 4) is that in which for a normal accommodative effort there is an exaggerated convergence response.

That accommodation, or rather accommodative innervation, is the usual causal factor can be demonstrated quite simply by varying the accommodation when the two eyes are fusionally dissociated and fixing at near. Concave and convex lenses added with fixation controlled at the near point will result in a change in the near point heterophoria toward the esophoric and exophoric sides respectively.

Clinical experience has shown that perhaps the most usual cause of an exaggerated response to normal stimuli such as the excessive convergence response discussed in this paper is emotional tension, and a permanent cure is not obtained until this is relieved, although ocular comfort may be attained with suitable glasses.

Accommodative convergence, in any case, may be found by carrying out the following mathematical procedures, thus obviating the need for diagramming the various positions of the visual axes:

1. Find the *physiologic exophoria*, or *physiologic esophoria* by subtracting, algebraically, the distance lateral heterophoria from the near lateral heterophoria.

2. Subtract the *physiologic exophoria* from the *total convergence*. The total convergence is the amount of convergence between parallelism and fixation at the near point (usually 1/3 meter) and is usually considered as about 18Δ (the exact value for 60 mm. pupillary distance). The result will be the *accommodative convergence*.

3. If *physiologic esophoria* is found, its numerical value must be added to the amount of the total convergence (18Δ) in order to find the *accommodative convergence*.

Example: 1. Esophoria for distance = 2Δ
2. Exophoria for near = 6Δ
3. (2) — (1) = physiologic exophoria = 8Δ
4. Total convergence (T C) = 18Δ
Accommodative Convergence = 18Δ − 8Δ = 10Δ

SUMMARY

The first requirement in the precise diagnosis of nonparalytic binocular imbalance is to classify the abnormality on the basis of the preceding discussion into one or more of the following groups:

1. Abnormal basic (tonic) vergence
2. Inadequate or absent fusional vergence
3. Excessive accommodative convergence

Diagnostic procedures may be either objective, utilizing prism cover testing, or subjective, with phorometer rotary prisms. The latter method is preferable if the patient is able to respond acceptably, not only because objective fusional vergence tests present difficulties, but also because of the ease and rapidity of the subjective procedure.

Cases in the first category, those exhibiting abnormal tonic vergence for distance, can be corrected either by modifying the distribution of tonic reciprocal innervation by exercise, increasing the type of fusional vergence amplitude which opposes it, or by reducing the heterophoria by surgery.

Inadequate fusional vergence cases, which make up the second group but which have not been discussed in this paper, are best treated by exercise or, in suitable cases such as those with vertical heterophoria, relieved by prisms.

For the excessive accommodative convergence cases, those which are the subject of this paper, immediate relief may be afforded the patient by the prescription of added convex lenses for near-point work as a temporary expedient until a greater stability of the nervous system is achieved. The easiest way to determine the added power required is to add convex lens power binocularly with fixation at one-third meter under prism fusional dissociation with a 6 diopter prism base down until ortho-

phoria or exophoria is obtained. The added convex lens power required can be then prescribed as an add in bifocals or together with the lens requirements for distance in glasses for use only at the near point.

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LATENT NYSTAGMUS

WILLIAM M. MCCARTY, M.D.
PHILADELPHIA, PENNSYLVANIA

NYSTAGMUS is usually classified as neurologic, otologic or ocular, and sometimes as labyrinthine or ocular. However, I prefer the classification of Cogan[1] in which emphasis is placed on the objective characteristics of eye movements as well as their etiology.

OBJECTIVE CLASSIFICATION OF NYSTAGMUS
(modified from Cogan)

1. Pendular nystagmus
2. Jerk nystagmus
   a. Opticokinetic
   b. Vestibular
   c. Nystagmus from neuromuscular insufficiency
   d. Congenital
   e. Latent

Pendular Nystagmus

Pendular nystagmus is characterized by oscillations which are roughly equal in the two directions. It occurs with, and is due to, the absence of central fixation.

Jerk Nystagmus

Jerk nystagmus, as one can see from the table, is subdivided into five groups.

a. Opticokinetic nystagmus is due to the following reaction and is perhaps most familiar to us as that nystagmus which occurs on gazing out of car or train windows. This is also the type of nystagmus which occurs when using the opticokinetic drum.

b. Vestibular nystagmus has as its etiology, the inequality of the sum totals of impulses from the semicircular canals of the two labyrinths.

c. Neuromuscular insufficiency nystagmus is manifested in a wide range of situations varying from an inability to maintain extreme lateral conjugate gaze (occurring in normal individuals) to marked paresis of conjugate gaze (occurring in those persons who have muscular or neurological defects). Due to the weakness of conjugate gaze, the eyes drift back toward a more relaxed position and the quick corrective movements jerk the eyes back toward the position of fixation, thus producing the nystagmus. This type of nystagmus depends on fixation and attention because if the eyes are allowed to drift away from their strained position, the nystagmus ceases.

d. Congenital nystagmus may be pendular as well as of the jerk variety. The cause in many cases is obscure, but some cases appear due to dominant or sex-linked recessive characteristics. Opticokinetic and vestibular responses are frequently abnormal. Some types of latent nystagmus are classified under this heading.

e. Latent nystagmus (also known as occlusion nystagmus) is characterized primarily by the absence of nystagmus when both eyes are open and a similar clear image is presented to each eye, but the presence of a jerky nystagmus when either eye is occluded, with the fast component toward the side of the open eye. If other criteria of latent nystagmus are present, some authors include with this entity the condition in which gross nystagmus is present with both eyes open and is made more pronounced upon occlusion of either eye.

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Upon the development of the nystagmus, the visual acuity promptly falls in direct proportion to the severity of the nystagmus. Thus, one of the usual characteristics of the entity is that the visual acuity is markedly better with both eyes than with either eye alone. The fall in visual acuity can be demonstrated to be due directly to the nystagmus, for if the conjunctiva is anesthetized and the open eye held still by such means as forceps, the visual acuity is found to be much better than if the nystagmus is given free play. Usually, the nystagmus is decreased when the gaze is directed toward the side of the uncovered eye, and several patients in the series being reported had habitual head turning to accomplish this adduction of the fixing eye. The intensity of the nystagmus varies according to the visual acuity of the eye covered. If the two eyes differ in their visual acuity, covering the eye with the better visual acuity produces the most violent nystagmus. Likewise, covering the eye with poorer visual acuity produces less marked nystagmus.

LATENT NYSTAGMUS

Characteristics

1. Nystagmus is not present when both eyes are open.

a. However, congenital nystagmus, in which the gross nystagmus is more marked upon occlusion of one eye, is placed in this group by some authors.

2. Nystagmus occurs upon occlusion of either eye, but not necessarily to the same degree.

3. Nystagmus is of the horizontal "jerking" type, with the rapid phase toward the side of the uncovered eye.

4. No nystagmus is present when both eyes are closed (determined by palpation through the lid).

5. The nystagmus is usually accompanied by neuromuscular anomalies (strabismus, etc.).

Common Features

Nystagmus usually occurs with (a) blurring of the vision of one eye by plus or minus lenses; (b) bright illumination of one eye; (c) reducing the image brightness of one eye by a graded photometric wedge, red lens or dark glass; (d) convergence; (e) lateral conjugate gaze (must guard against blocking the vision of one eye with the nose). It may or may not occur with displacement of the image by prisms placed base up, down, in or out. The nystagmus is usually less when the open eye is adducted.

Other Characteristics

1. Nystagmus is present from infancy and supposedly remains unchanged throughout life.

2. If one eye is removed, the nystagmus of the remaining eye persists but may gradually decrease in intensity.

3. Labyrinthine nystagmus (either caloric or rotary) takes its usual form, but if latent nystagmus is elicited also, the resultant nystagmus is the algebraic sum of the two.

4. Nystagmus produced by use of the opticokinetic drum is similar to labyrinthine nystagmus.

Although Cogan[1] has stated that latent nystagmus is usually not accompanied by strabismus, monocular amblyopia and so-called alternating hyperphoria, Kestenbaum[4] is of the opinion that latent nystagmus is almost always accompanied by strabismus, and this series of cases bears this out.

[A motion picture showing a typical case of latent nystagmus was shown.]

Time does not permit a review of the literature. Latent nystagmus was first described by Faucon[2] in 1872, but it was not until the Fromaget brothers[3] collected a total of 10 cases that it was established as a clinical entity. Since that time, a number of cases have appeared in the literature. Kestenbaum reports having seen more than

one hundred cases; yet, actual reports on the entity are somewhat sparse, giving the impression of rarity.

A series of 40 cases was collected at Wills Eye Hospital by going through files of the orthoptic department and by personal collection over the past sixteen months. Although statistics can be boring, some are necessary, and I have tried to limit these to the most pertinent ones.

I. Age: The age of the patients in the series varied, the youngest patient being 14 months of age (the diagnosis was confirmed by subsequent examinations) and the oldest, 60 years. Six of the patients were over 20 years of age.

II. Heredity or familial incidence: Each of the patients or parents was asked concerning the possibility that other members of the family had experienced a similar phenomenon. In cases in which it was possible, the mother, father and siblings were tested. In one case (M.B.), the mother was found to have latent nystagmus. Both mother and daughter had an associated esotropia; alternating esotropia in the mother and a left esotropia with a left hypertropia in the daughter. So far as is known, this is the first reported case where there was any familial association. Though interesting, it is felt that this is merely coincidence.

III. Associated ocular defects: In the total of 40 cases, the associated ocular defects were as follows:

Esotropia with alternating hyperphoria (two became exotropic with surgery)	16
Esotropia with left hyperphoria	5
Esotropia only	10
Alternating hyperphoria only	4
Exotropia only	2
Phoria	3

IV. Fusion status: The degree of fusion was tested on the synoptophore with the following results in the 40 cases:

None (meaning suppression)	14
Abnormal retinal correspondence	5
Simultaneous perception but no amplitude	13
Single binocular vision with amplitude	5
Stereopsis	3

V. Surgery: 14 of the 40 cases had varying amounts of surgery with varying degrees of success. In 3 cases the eyes became grossly straight, in 3 the degree of squint was reduced, and in 5 there was no improvement. Two cases of esotropia became exotropic, and 1 case of exotropia became esotropic.

VI. Patching: Although one would ordinarily think that patching would be a poor procedure in these cases because of the nystagmus that would ensue, 8 cases had some form of patching. In 5 of these cases the results were inconclusive either because patching was done prior to the initial visit to our office or because visual acuity was undetermined prior to patching. However, even in these cases, the visual acuity was better than 6/60 despite the nystagmus.

In the 3 cases that could be followed, one patient (W.T.) had a visual acuity of 3/60 O.D., brought up to 6/12 in a period of six months between the ages of 3.5 and 4. The second (M. G.) at age 4 had a visual acuity for the right eye of 1/60, which was improved successively to 6/60, and then 6/6, by patching over a period of six months. The third patient (S. K.) at age 4 had a visual acuity of 6/60, brought up to 6/9 over a period of six months.

What does latent nystagmus mean to the orthoptic technician? Of prime importance is simple recognition. The girl whose case was presented in the motion picture was referred to the clinic at Wills Eye Hospital simply because her vision when tested at school was 6/30 in each eye. The refractive error was minimal, and due to her good binocular visual acuity, no glasses were ordered.

Second, surgery, if performed, is primarily cosmetic although occasionally second degree fusion occurs. In no cases did

stereopsis occur after surgery, despite intensive orthoptic training in some of the cases.

Third, latent nystagmus should be thought of in cases of neuromuscular defects. While one would expect the 21 cases found in the orthoptic files to be strabismic or of similar nature, 19 of the 40 cases, or nearly half, were picked up incidentally, and 16 of these 19 "incidental" cases showed some degree of neuromuscular anomaly.

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CONVERGENCE INSUFFICIENCY

NED W. HOLLAND, M.D.
TAMPA, FLORIDA

CONVERGENCE insufficiency is a malady commonly seen by the practicing ophthalmologist. It is a condition that can readily be diagnosed if all of the cardinal points of a routine muscle examination are carried out. Unfortunately though, in many instances, in an effort to correct convergence insufficiency the only treatment given is correction of the refractive error, with the result that the complaints persist or grow worse. Consequently, these patients may visit several ophthalmologists before they find one who takes the time to do a routine cover-uncover muscle test, a prism vergence test, a check of the near point of convergence, and a diplopia test.

In a series of 30 patients with convergence insufficiency from our orthoptic clinic, it is interesting to note that 60 per cent were females between 15 and 44 years of age. Four children between 6 and 11 years of age were included. Twenty-seven of the group had hyperopia or hyperopic astigmatism, the highest refractive error being corrected with a plus 1 sphere. The remaining 3 patients were myopic.

The symptoms of convergence insufficiency fell into a general pattern, the dominant complaint being eye strain. However, many other complaints, such as localized or generalized headache noted when reading intently, fatigue, a tendency to fall asleep at work, pain in the eyes, redness of the eyes, poor reading ability, difficulty in focusing, nervousness, irritability, and dizziness, were elicited.

This condition is unusual in early childhood. Since the onset is after the binocular habits are well formed, amblyopia seldom occurs. Fusion is good, and asthenopia occurs frequently because fusion is achieved under difficult circumstances. Exophoria is greater for near than for distance; the near point of convergence (NPC) is remote, and the prism convergence may be poor or within normal limits but poorly sustained, and thus productive of symptoms.

Convergence insufficiency is usually considered to be functional in origin

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although it may be organic. As a rule it is caused by fatigue, illness, neurasthenia, visual inattention, uncorrected acquired myopia, uncorrected presbyopia, or a deficiency in accommodation. Any of these conditions may result in a lack of stimulation to convergence. Any condition which makes accommodation unnecessary or impossible will weaken convergence and will tend to produce a relative divergence.

In the treatment of convergence insufficiency the underlying cause must be considered. High hyperopia, with or without astigmatism, results in inability to accommodate, so the person stops making the effort. When no accommodative effort takes place, no convergence occurs. If untreated, these patients may develop a manifest exotropia. The treatment should be an undercorrected full refraction at first, to be altered as the patient's need and tolerance will later demand. Vigorous convergence exercises are frequently necessary.

Convergence insufficiency with secondary divergence excess is one of the most common types of strabismus. It is usually seen as pure convergence insufficiency, though many patients have some phoria at distance as well. A remote NPC is the first clue, and slight to large exophoria may be demonstrated on screening. This type of strabismus is most successfully treated nonsurgically with intensive convergence exercises; though the degree of exophoria may not alter, the NPC will improve, and with its improvement symptoms will abate. The ophthalmologist may be fooled by a normal NPC achieved by previous orthoptic training which may have been insufficient and may bear repeating. If the secondary divergence excess is a manifest tropia, surgery is the treatment of choice. Resection of the medial recti, combined with recession of one or both lateral recti if larger degrees of strabismus are present, is the preferred surgical procedure. It rarely results in overcorrection. Amblyopia, if present, must be vigorously treated prior to surgery for best results.

Convergence insufficiency associated with acquired myopia, usually with onset during the school age and in the later teens, is best treated by full correction of the refractive error. At times, the patient may be overcorrected if the glasses are to be worn constantly. If the convergence is still deficient after the glasses have been worn, simple convergence exercises can be started. This type of convergence insufficiency usually responds well to orthoptic treatment.

If the convergence insufficiency is due to or associated with presbyopia, adequate correction for near should be given, a well-regulated life with some outdoor activity should be suggested, and more vigorous convergence exercises should be begun. Normally as accommodation weakens during presbyopia, convergence becomes more difficult.

When the convergence insufficiency is due to ill health, pregnancy, fatigue or neurasthenia, the obvious answer is rest, sleep and graded physical activity. Psychiatric consultation hardly need be suggested. Eye exercises are poorly tolerated until the general health or state of the nervous condition has been improved.

The treatment of convergence insufficiency presents frequent opportunities for the orthoptic technician to exercise her abilities, and the satisfaction of the patient is gratifying. Convergence exercises are frequently poorly conceived and administered. The simplest exercises may be effective if they are adequately and carefully explained to the patient and if the patient is made to feel that they are important. More often than not, complicated and impressive gadgets are necessary to impress the patient and produce results.

The following convergence exercises are commonly used:

1. Finger or pencil to nose exercises. These exercises simply require the person

to look at the end of the finger or pencil while it approaches the nose and to make the effort to keep that object single and clear. They are frequently ineffective because such commonplace objects fail to stimulate the patient's interest. This is particularly true with children.

2. Picture to nose exercises. This is a variant of the finger to nose exercise. Cards bearing pictures or words are brought gradually closer to the nose. The child is questioned about the picture or word presented in order to keep his interest and attention constantly stimulated.

3. Prism convergence exercises. This type of exercise is particularly effective for and applicable to the presbyopic patient since it stimulates convergence with little or no stimulation of accommodation. In this exercise the patient is asked to fixate a light at 13 inches. Base-out prisms are introduced in gradually increasing strengths; with each change the patient sees the object double and with effort makes it single again. As the prism strength becomes greater, so the amount of convergence required becomes increasingly great; the amplitude of convergence is increased accordingly.

4. Stereoscopic exercises. There are various series of slides which stimulate convergence on the stereoscope. Some of these are the Wells, Cruise, Guibor, and Keystone slides. The Keystone slides which are convenient to use are the base-out slides of the Alpha, Delta, and Gamma Series. The patient is instructed in the use of the slides, and is told to use them in broken periods of not more than 10 minutes, two or three times a day.

5. Rotoscope and metronoscope exercises. Since the latter instrument is a pair of Risley prisms, it is possible to place rolls of target material, consisting of words or sentences in sequence, in any order and set at any speed desired. To increase convergence, the patient learns to read readily at a good speed with the prisms set at zero and to continue to read as the base-out strength of the prisms is gradually increased.

6. Major amblyoscope exercises. The major amblyoscope is probably the most effective of the instruments used. The arms of this instrument can actually be changed so as to give an increased necessity for convergence and divergence. There is a wide variety of target material which can be shown at several degrees of illumination.

The exercises with the major amblyoscope, the metronoscope, the rotoscope, and other similar equipment are often necessary as a primary procedure. Many patients with a convergence insufficiency either cannot be interested in the simple exercises and will not carry them out, or receive too little stimulation from the exercises to benefit from them. In such cases, exercises should be done in the office frequently, every day if possible. As the individual gains convergence ability and realizes the importance of what he is doing, an increasing number of the exercises may be done at home.

SUMMARY

Attention has been directed to the common occurrence of convergence insufficiency; its causes, symptoms, and methods of treatment have been outlined. The necessity of an adequate examination of all patients of the ophthalmologist for discovery of convergence insufficiency and similar conditions has been elaborated.

OCULAR TORTICOLLIS

A. P. PERZIA, M.D.
TAMPA, FLORIDA

THE subject of ocular torticollis has been very interesting to me. Several years ago two children, one nine years of age and the other twelve, were brought to my office on two different occasions for examination of their eyes. Their histories were very similar. The parents in each case stated that their child had had a tilted head or wry neck practically since birth. In trying to find a cure for this condition, they had consulted an orthopedist, who advised and placed a corrective neck collar to correct the distortion of the neck. From the time he did this, both of these children started to complain of double vision and confusion in reading and getting around, so the parents brought them in for eye examination. We found that on removing the corrective collars, the head tilt returned in each case, but the child's eye trouble disappeared. On further examination we found that one child had a paresis of one superior rectus muscle with an overaction of the inferior oblique muscle of the opposite eye. The other child had a paresis of the superior oblique with an overaction of the opposite inferior rectus. Recession of the inferior oblique in the first case gradually caused a straightening of the head and comfortable binocular vision. Recession of the overactive inferior rectus in the second case resulted in correction of this child's head tilt after four months, and the child had comfortable binocular vision.

The subject of torticollis should be of interest to the pediatrician and the orthopedist as well as the ophthalmologist. Wryneck, or torticollis, may be brought about by several causes, such as cervical adenitis secondary to tonsillitis, pharyngitis and peritonsil abscess. It may be caused by diseases of the cervical spine such as osteomyelitis, arthritis, and fractures. It may also be due to congenital or acquired contractures or spasms of the sternocleidomastoid muscles or to myalgias of the cervical muscles. When only the sternocleidomastoid muscle is involved, the head is inclined to the affected side and rotated to the opposite side. The chin is raised and the ear approaches the sternoclavicular joint. There is no eye muscle paralysis or squint in these cases.

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OCULAR TORTICOLLIS

In ophthalmic practice many abnormal positions of the head and neck are seen as the result of imbalance of the ocular muscles. A slight degree of head tilting is observed in many infants, due to incoordination of the eye muscles, which disappears by the second year. Marked head tilt is evident as the result of paralysis, congenital or acquired, of the elevator or depressor eye muscles.

Ocular torticollis may be defined as a compensatory adjustment or tilt of the position of the head to overcome vertical diplopia. Head tilt results from a combination of visual and neuromuscular impulses. In general, the head is tilted to the right in cases of paralysis of the right elevator and depressor muscles: right superior rectus, right inferior rectus, left superior oblique and left inferior oblique; and tilted to the left when the four opposite muscles are affected: left superior rectus, left inferior rectus, right superior oblique and right inferior oblique. For example, to overcome the double vision and visual vertigo induced by paralysis of the right

superior rectus muscle, a child has three means of relief: (a) cover or close the right eyelids; (b) tilt head to the right to bring the diplopic image down to level of that seen by the left eye; or (c) develop convergent or divergent strabismus so that only one image is seen.

A large number of cases of horizontal strabismus seen in our office are outgrowths of vertical muscle paralysis. Alexander Duane[5] states:

> A condition that favors the development of a lateral squint is the presence of a congenital vertical deviation, especially a paralysis of the superior rectus. The patient in this case being unable to fuse the double images on account of the difference in level, tries to obviate the confusion by either tilting the head or separating the images as far as possible. This he does by diverging or converging the eyes.

Duane continues:

> That this is the cause of the lateral squint in these cases is proved by the fact that in some of them, particularly before the lateral deviation has become inveterate, the lateral disappears when the vertical deviation is relieved by operation.

CASE REPORT

Dr. Duane's statements can be seen to be true in the following case. Two months ago, a three-year-old child was brought to my office for eye examination. The history in this case was that the child's eye had turned in since birth. She had undergone surgery at three different times by an ophthalmologist. The hospital records showed that only the horizontal muscles in both eyes had been operated on during the surgical procedures, but the child still had not only an alternating convergent strabismus of about 15 prism diopters but also an upshoot of both eyes when one eye or the other was adducted. If the eyes were turned to the right, the left eye would come up and in, and if the eyes were turned to the left, the right eye would shoot up and in. A diagnosis of bilateral superior rectus muscle paresis with overaction of opposite inferior obliques was made. There was no torticollis. A recession of both inferior obliques corrected not only the upshoot but also the convergent (horizontal) squint. This brings us back to the above statement that a child may develop a convergent or divergent squint in order to overcome vertical diplopia and visual vertigo induced by a paralysis of one of the vertical muscles.

The most frequent and important type of paralysis of a single vertical motor anomaly is paralysis of the superior oblique muscle. The most striking sign is a habitual torticollis, that is, a tilting of the head to one shoulder. This occurs most often when the oblique muscles are involved, either the superior or the inferior oblique. It usually does not occur as markedly when the superior or inferior recti are paretic.

The ocular origin of torticollis is often not recognized, particularly in cases of congenital trochlear nerve paralysis (paralysis of the superior oblique muscle) or that acquired in early childhood. The explanation given by Bielschowsky[1] follows:

> Wheel-like rotation of the eyes on their anterior-posterior axis is due to a reflex innervation of vestibular origin. The parallel rotary movements on the anterior-posterior axis can only be brought about by the superior muscles of one eye, the superior oblique and the superior rectus, both of which rotate the right eye on its anterior-posterior axis to tip the vertical axis inward, that is, to the patient's left (these muscles are intortors). At the same time the inferior muscles, the inferior oblique and the inferior rectus, the outward rotators or extortors of the left eye, rotate this eye to the left when the patient's head is tipped to the right shoulder.

Thus the combined action of the superior muscles, inward rotators of one eye together with the inferior muscles and outward rotators of the other eye results in the rotation of both eyes to the left when the head is tipped to the right. When the head is tipped to the left both eyes rotate to the right on their anterior-posterior axis. The physiological explanation of the wheel-like rotations of the eyes on their anteroposterior axis has been reviewed here, since it is most helpful in understanding (1) ocular torticollis; (2) the movements of the eye in tipping the head to one shoulder and then to the oth-

er; (3) the differential diagnosis of paresis of an oblique and that of a superior and inferior rectus.

Obviously the patient must be able to achieve binocular single vision; that is to say, he must have sufficient good vision in each eye and adequate fusion to appreciate diplopia. The torticollis is invoked by the patient to prevent diplopia. He achieves this by so placing his head that his eyes are brought into that position in which they will not be in the field of action of the paretic muscle. The chin is also depressed if a depressor muscle is paralyzed, and elevated if an elevator muscle is paralyzed.

As an example, in a case of paresis of the right superior oblique, tilt the head toward the right shoulder. This will produce a vestibular reflex excitation of muscles which cause a parallel rotary movement of both eyes to the left. This movement is produced in the left (sound) eye by the inferior verticals or extortors, and in the right (paretic) eye by the superior verticals (intortors). This causes a negative cyclophoria of the right eye due to the inability of the right superior oblique to intort the right eye. The unopposed action of the right inferior oblique and inferior rectus causes extortion of this eye. The paralyzed right superior oblique can no longer oppose the action of the right superior rectus and the right inferior oblique; consequently the right eye turns up. The unopposed action of the right superior rectus also causes the right eye to turn in. Hence, with the head tilted to the right, in paralysis of the right superior oblique there will be found the maximum vertical deviation of the right eye.

The vertical deviation on tilting the head to the paretic side is the outstanding and diagnostic symptom. On tilting the head to the left, there is no deviation of the paretic eye. The vestibular innervation to rotate the eyes around the visual axis to the right goes only to the inferior verticals of the right eye. Since the paretic right superior oblique receives no impulse and hence is not called upon to act, there is no deviation of this eye.

The early diagnosis of ocular torticollis by the pediatrician or orthopedist would obviate application of corrective collars and surgery on the sternocleidomastoid muscle. Many convergent strabismus cases operated upon years ago became divergent cases postoperatively because the eye surgeon failed to recognize a head tilt or basic underlying vertical muscle paralysis.

No eye surgery should be undertaken until medical means of correction have been exhausted. Routinely, all errors of refracting should be corrected. Patients with small amounts of hyperphoria may be relieved by wearing prisms and by orthoptic training. The term ocular torticollis should be reserved only for marked cases of head tilt with associated skeletal changes. If the deformity is not excessive and causes no discomfort eye operations may not be indicated.

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NEUROLOGICAL AND PSYCHOLOGICAL BENEFITS OF SUCCESSFUL STRABISMUS THERAPY

SHERMAN B. FORBES, M.D.
TAMPA, FLORIDA

EXCEPT for restoring sight to the blind, the successful treatment of strabismus, particularly in infants and children, is probably the most spectacular accomplishment of the ophthalmologist. A squint in a child's eye is frequently a very serious condition. It may affect his entire life profoundly, especially psychologically and economically. The condition, therefore, must be recognized early if it is to be corrected. The squinting child's handicaps, both direct and indirect, are varied. The primary physical handicap is a decrease of useful vision in one eye. Secondarily, the child loses binocular single vision and suffers a corresponding loss of spatial and distance judgment. Later in life, when he should become a useful citizen, these combined physical defects create a serious economic problem by limiting employment and perhaps warping personality.

Psychological Factors

The squint is a social stigma which harasses most patients all of their lives. Early in life it may lead to a psychological state characterized by a feeling of inferiority. Strabismic children are often subjected to derision by their young associates, who wittingly or unwittingly make them the object of their jokes. The resulting psychological trauma is carried on into later life and may exert a continued detrimental effect on social status.

In children, loss of binocular vision and fusion naturally creates an unfavorable psychological reaction. Comparatively little thought has been given to the far-reaching mental effect which a deforming squint has upon the child. Parents may fail completely to realize that the psychological problem is actually, or potentially, greater than the ophthalmological problem. The child soon becomes conscious that he is different from other children and that this difference is not to his advantage. This realization marks the beginning of an inferiority complex. The first response of the child is withdrawal from the group with a feeling of being different and unwanted. He becomes shy and timid. Adults will testify to the anguish they experienced in early childhood as a result of this defect and to the influence which it exerted upon their lives.

From the psychological viewpoint, the cross-eyed child requires development or re-establishment of the normal human relationships which are so important in a child's life. The physician should make definite efforts to combat feelings of inferiority, shyness, timidity, or aggressiveness which are present as a result of the strabismus. If the child is later to develop into a healthy, normal adult, it is essential that he be made to realize that he is like other children.

Economic Problem

Strabismus creates an economic problem. When the child with this handicap reaches adulthood, he is limited in the positions he may obtain, particularly in industry, where good vision in both eyes usually is demanded. Many men and women, otherwise fully qualified, must be excluded from occupations and vocations which call for binocular and stereoscopic vision. The majority of

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young people who have suffered from squint with loss of vision in one eye will be unable to gain employment in most industries, for they require visual tests. As the demand for safety increases, greater stress is placed on physical ability.

Causative Factors

General diseases which affect extraocular muscle or innervation include disease processes which affect the sensory paths in the eye and the motor nerve trunks, nuclei, or nerve tracks between the nuclei and trunks. Head injuries at birth, intracranial hemorrhage, intracranial tumors, neoplasms, encephalitis, myasthenia gravis, disseminated sclerosis, aplasia of motor nuclei, neurosyphilis, poliomyelitis, muscular and atrophic disturbances of ocular motility and senility, toxic effects of diphtheria, toxic goiter and thyrotropic factors are mentioned in this connection.

Strabismus may result in any of these conditions. Such cases are medical and not strictly orthoptic problems. Strabismus is sometimes associated with other abnormalities; in persons with deterioration of physical and mental powers it may accompany signs of abnormal development such as abnormal size and shape of the cranium, facial asymmetry, high palate, malformed teeth and other deformities of the nose, ears, hands, feet and fingers. There may be functional anomalies, such as stuttering, left handedness and certain forms of chorea, along with such psychological difficulties as retardation in reading and mental blocks to the learning process.

It is important to realize that squint or strabismus in children is frequently associated with birth trauma, infections in the mother resulting in fundus lesions which cause an amblyopic eye in the offspring, and diseases involving the nervous system. Most of the children have a neuropathic background. In other words, the squinting child frequently has associated disturbances of the nervous system which might be described as a lessened nervous and physical reserve, which must be recognized and combated. It is always my feeling that children of this type represent the unusual group, and even in the administration of an anesthetic we watch them a little closer than we would the more normal child.

Therapy

According to Fink, squint occurs in about 0.5 per cent of the children in this country. The physician must stress the point that early treatment is vital and that the child will not, as a rule, outgrow the squint. The cases of strabismus in which the defect corrects itself are indeed few and far between. The successful treatment of strabismus requires elimination of a bad habit and establishment of a proper one as well as discovery and correction of any obstacles to binocular single vision resulting from lack or loss of global alignment.

There are two possible goals in strabismus therapy, cosmetic cure and true functional cure. In almost every case, cosmetic improvement of eye alignment can be obtained; however, only in two eyes that perform as a pair do we have a good guarantee of life-long parallelism.

Strabismus is not a disease in an ordinary sense, since it is not an infection or an allergy or the result of trauma, nor is it a new growth. Rather, it is a symptom and evidence of failure to develop complete integration in the more special senses. No other special sense calls for such a high level of cooperative organization as does binocular single vision. It is no wonder that occasionally the development of such a complex system falls short of perfection.

No one cause for strabismus exists since there are numerous obstacles to fusion. As previously mentioned, associated defects frequently of the central nervous system, unusual shape of the eyeballs, fundus lesions, paralysis of extraocular muscles due

to birth injury or disease, and a highly nervous makeup are factors which frequently must receive major consideration in therapy. It is my opinion that the crossed eyes of most children have a distinctly psychosomatic etiology. It is also my observation that the parents, particularly the mother, frequently are most difficult to handle and most emotional. This is a factor we must recognize in the treatment of the child. Neither the parents nor the child has the calm phlegmatic personality that is so desired in these hectic days.

It is difficult to fit the complex anomalies of binocular vision into simple clinical classifications; however, the detailed study of the pathologic physiology of the patient's binocular vision is essential in the successful handling of all or most cases of strabismus. We are faced with a squinting child today for whom we must do everything that is currently possible.

Most ophthalmologists agree that treatment should begin soon after the first crossing of an eye. With today's therapy, two thirds of the children with squint have potential binocular single vision. This theoretical limit is derived largely from the fact that among the 20 per cent of patients who have exotropia, there are many in whom the condition dates from birth, and the function of binocularity is therefore obviously impossible. In about one third of the 80 per cent with esotropia, the condition is not favorably influenced. Unless binocular single vision is potentially achievable and unless parents, child and ophthalmologist are ready to spend sustained and most extensive effort to obtain it, it is better to defer surgery for mere cosmesis until the child is of kindergarten age. In time, following operations for cosmetic effect alone, there is loss of the straightness achieved.

There is general agreement among those best qualified to judge that children with crossed eyes should have them straightened early in life. Just as one would correct a child's lame leg, when possible, before he learns to walk, so a child's crossed eye should be corrected before he needs to use it in teamwork with the other eye. This goal is attainable for practically every cross-eyed child whose defect is treated in a manner consistent with present-day concepts.

Neurological and Psychological Benefits of Successful Therapy

The cross-eyed child seldom complains to his parents. Rather, he assumes that his is a somewhat abnormal pattern of behavior, and he reacts in one of two ways to the severe emotional experience to which he is subjected. Children are often unconsciously cruel, as they quite openly discuss such defects as crossed eyes among themselves and freely bestow descriptive nicknames on their unfortunate playmate. Understandably, he withdraws from the group, becomes shy and timid, shuns other children, and hides behind his parents when strangers are present. He becomes introverted and spends his time with books or in games in which he can be master in his own imagination. In a very real sense he suffers from an inferiority complex and a feeling of not belonging. Less frequently, the reverse is true. The child becomes loud, boisterous and aggressive, particularly with children younger than he. As he attempts to compensate for his defect by assuming qualities which others do not have or display, he becomes the terror of the neighborhood. Either reaction makes for an altered personality which may continue into adult life and become permanent if the defect is not corrected. It is deeply gratifying to see the beneficial psychological effect attained by giving such a youngster a straight pair of eyes. The entire pattern of his behavior may change within a few months after the return to ocular normalcy.

It has been my good fortune to have a rather wide experience in strabismus thera-

py with many cases treated under my supervision, either by surgery alone or by surgery combined with orthoptics. In the majority of cases, the combined therapy constitutes the ideal therapeutic procedure. It affords me genuine pleasure to reiterate here that among all the spectacular results in the practice of ophthalmology, the successful conclusion of an operation for strabismus is one of my most gratifying experiences.

As I look back over a considerable period of years in the practice of ophthalmology, I recall, in particular, a strabismic child seen first when he was 4 years old. Of the emotional and garrulous type, he gave his mother a severe kick on the shin during the first examination. That child was successfully treated with combined surgery and orthoptics. He is now married, and today is one of the staid, complacement members of the community, a great success in his business, family and social life.

In looking through my files, I noted a hundred unselected cases in which the patient had been cured of strabismus and in which binocular function had been restored. In all of these cases, the resulting emotional and nervous stabilization and the cure of the introversion and sometimes garrulous excitability were truly spectacular. To one who has been in a community as long as I have been in Tampa, the opportunity of observing lasting results is available. My observations lead me to stress again that the early cure of strabismus, both cosmetically and functionally, with the institution of binocular function, is one of the most rewarding procedures in ophthalmology.

Contrary to the opinion of some authorities, it is my firm belief that in certain types of esotropia, surgery can be instituted even before the child is one year of age. When the deviation is monocular, I believe that resorting to early surgery avoids the sequela of pronounced muscle contraction due to lack of function of the antagonist. This operative procedure is not difficult. I have performed it on a large number of patients and have never seen a resultant external deviation. Frequently it is necessary to recess the internal rectus of the opposite eye, for apparently most of these esotropias are of the alternating type. The improvement is most striking both in the physical and mental progress of the child.

I would not leave the impression that the benefits to the nervous system are experienced only when the patients are infants or children. Certainly such benefits are experienced by adult patients also. I recall the recent case of a young woman with a traumatic paresis of the sixth nerve. I performed a classical Himmelsheimer operation, with which I am sure most of you are familiar. It consisted of transplantation of strips of the superior and inferior recti to the paretic lateral rectus, with a resection of the lateral rectus, and a recession of the mesial rectus. The result was binocular single vision in the primary position, first and second degree fusion and, I am proud to say, a slight exophoria at near. The change in this young woman is astounding. There has been a remarkable improvement in her personality; she has resumed her position and is planning marriage. Prior to the surgery she was an invalid.

In many instances convergence insufficiency in crossed eyes is helped by muscle surgery even in the mature age group. In any prolonged effort at reading, this defect causes a great deal of difficulty. Of course, the surgery must be preceded and/or followed by orthoptic training. Many adults as well as children have been benefited both psychologically and physically by correction of strabismus.

I should like to leave with you this thought: in most cases of strabismus, nothing can be more beneficial to the nervous system of the patient than a correction of the deviation. The personality of the

younger person may be entirely changed, and in selected cases, the benefit derived by the older person is almost as dramatic. I would not leave the impression that all the cures are effected by surgery. In my experience a combination of surgery and orthoptics has shown the most spectacular results. Nevertheless, I can select cases from my files in which only orthoptics has been used along with proper refraction, with equally fine results. The attainment of this goal becomes a matter of teamwork between the ophthalmologist and the orthoptic technician, once the proper form of treatment is selected.

To the orthoptic technician as well as to the ophthalmic surgeon there is a challenge in strabismus therapy that brings its reward in gratifying results. The benefits that accrue to the patient successfully treated for strabismus are untold and of such magnitude that they cannot be overemphasized.

COMMENTS ON FIXATION DISPARITY

MARY LOUISE CRONIN, O.T.
ROCHESTER, MINNESOTA

THE term "fixation disparity" is fairly new to all of us, although it does not describe a new phenomenon. The phenomenon has been observed for a long time but is not clearly understood. It has been described by Hofmann and Bielschowsky[2] as a "lag," and by Ames and Gliddon[1] as a "retinal slip."

First of all, fixation disparity has nothing to do with tropias or squints. It is an exhibition of a phoria while the fusion of similar images is maintained. The fixation disparity can be measured only if the patient has good visual acuity and no suppression. The troposcope should be fitted with slides having both identical and dissimilar figures. The images of the identical figures will fuse readily but the dissimilar marks will appear displaced with respect to each other if phoria is present. If lateral phoria or muscle imbalance is present, the small disk will appear displaced within the large disk—displaced in the direction of the phoria. The direction and magnitude of this displacement of the small disk within the larger one can be changed by changing the angle of the arms of the troposcope. At some particular setting, two disks will appear to be centered. Then, for that angle we can say there is no motor imbalance, and this agrees, in a general way, with the heterophoric convergence.

The technique for determining fixation disparity has been described by Ogle and Prangen,[4] and again by Ogle[3] in the fourth volume of the American Orthoptic Journal. We know that the magnitude of displacement depends on the muscle imbalance, on the fusion reflex, and on the type of details for fusion on targets. The fixation-disparity test permits location of the change of muscle imbalance while fusion, normal convergence and accommodation are maintained. The effect of prisms, lenses, or change in convergence on motor imbalance is easily studied. It has been found that the measurements of motor imbalance by the fixation-disparity technique and by the Maddox rod will agree usually in regard to the direction of imbalance but frequently not in regard to the magnitude. It must be assumed, then, that when both eyes are active and the

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images are fused, the muscle imbalance may be different from that noted by the usual methods when fusion is suspended.

In one of our cases, measurements by the fixation-disparity test did not agree with the cover test or Maddox-rod test. The patient showed a right hyperphoria of 5 diopters when tested by Maddox rod. For distance, the fixation-disparity technique showed a right hyperphoria of only 0.75 diopter. The patient's fusion was therefore assumed to be excellent, and in view of the fact that the patient had no uncomfortable symptoms, no prisms were prescribed.

As yet this technique has not been developed for a routine clinical test, but we have used it to learn more about patients having phoria. As mentioned previously, fixation disparity has no connection with tropias but exists only with fusion.

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A PANEL DISCUSSION ON SMALL ANGLE ESOTROPIA

ELSIE H. LAUGHLIN, O.T.
IOWA CITY, IOWA

MARY LOUISE CRONIN, O.T.
ROCHESTER, MINNESOTA

LORRAINE LUCAS, O.T.
DETROIT, MICHIGAN

I
MISS LAUGHLIN

THE program committee deserves credit for bringing the subject of small degree esotropia into the open for us to tussle with.

During the past decade for most of us (and two decades for some of us), we have learned much about coping with the major problems of amblyopia, suppression and abnormal retinal correspondence (ARC). At least we know what we can do for these conditions if given the opportunity and how our better results have been achieved.

Those of us who have remained stationary geographically (and perhaps otherwise) have accumulated a number of patients with these enigmatic small angle squints for which we somehow feel responsible. It is time that we begin investigating these results further, even though we suspect that "cosmetic position satisfactory" is a fitting term for most of them.

I think that we are inclined to have a guilty feeling about these cases, and yet, as we examine the case histories, we find that these patients on the whole have had the same advantages as our better "functional result" cases.

With this panel discussion in mind, I picked at random twelve case histories of patients with small degree convergent deviations and have prepared mimeographed records of some of the findings which I thought might be significant.* I found nothing spectacularly different in the responses of these patients to glasses, occlusion, orthoptics and surgery when compared to the responses of the usual patient with squint. No attempt was made to show the advantages of orthoptic treatment and no patient received orthoptic training in preference to another patient. Orthoptic "readiness" was evaluated at each visit, and a series of five or six intensive treatments was given preoperatively or postoperatively when it seemed that such time could be spent to good advantage and the new skills could be practiced at home. Other patients who did not have a residual small degree esotropia had followed the same routine.

With the means we have at our disposal now, and keeping in mind that 1,200 cases would make a more satisfactory study than 12, we are not inclined to consider small degree deviations an overwhelming problem. However, we are in favor of finding out more about them. Compared with some of our earlier problems, this is definitely a "refinement" in the line of orthoptic endeavor.

I have permission to quote from Dr.

Read at the Midwestern Regional Meeting, American Association of Orthoptic Technicians, May 2-3, 1955, Milwaukee.

Burian's "Normal and Anomalous Correspondence" presented at the symposium in New Orleans:

> The findings of Adler and Jackson (Archives of Ophthalmology, volume 38, 1947) and Morgan and Flom, are in striking contrast to the findings of Jampolsky who has made special study of patients with a deviation of less than 15 diopters (A.M.A. Archives of Ophthalmology, volume 45, 1951). Using special targets he claims to have found that 92 per cent of these patients demonstrated ARC with a high incidence of anomalous peripheral fusion.
>
> These findings are disputed by Morgan and Flom who have shown that in the range within which these patients fall, the differences between objective and subjective angles are so small that they lie within the limits of accuracy of the method.
>
> Obviously these discrepancies are due to two related factors. One factor is the choice of the criterion by which a diagnosis of ARC is made, and the other is the type of test on which the diagnosis is based. Until such a time that it has been established by general consensus what we mean, clinically speaking, by ARC the figures of different authors about its incidence are rather meaningless when compared with one another.

No doubt many of you have studied the excellent discussion of 80 cases of small degree esotropia in the 1952 British Orthoptic Journal. The following conclusion is made:

> It was concluded that these patients maintained S.B.V. and had all the advantages of B.V. in spite of a slight manifest deviation and alleged angle of anomaly. It is suggested that this was not a true manifest deviation but merely a fixation disparity compatible with S.B.V. The fixation disparity was thought to be the result of the absence of bi-foveal fixation in B.V. as the result of the dominance of the peri-foveal over the foveal area, possible due to slight amblyopia.
>
> It is suggested that these cases should be treated in exactly the same way as cases of esophoria.

And so, as usual, progress will be the result of more accurate diagnosis and more well-defined terminology.

We not only need to distinguish between esophoria and esotropia for distance and near, with and without glasses, in the primary and diagnostic positions of gaze, under favorable conditions and on "off days" but, in those cases in which a fusional movement is present upon "uncover" test but falls short of accomplishing its purpose, we must also find a way to determine *how much* of that deviation can be called phoria.

This is one of the problems which the slide contest committee had in mind in specifying the type of targets which we would like to have entered in the slide contest this year. If any of you have been wondering what was meant in those specifications, I shall be glad to try to explain them. I am sure that someone will come forth this year with some slides especially adapted to gaining more information about small degree deviations. As a result, a diligent study of case histories may take on more meaning, and in a few years we can really look back on our efforts with some measure of satisfaction.

II

Miss Cronin

Small angle esotropia of 5 degrees or less is a frequent problem. Good functional results are desired in cases of strabismus, but so often stubborn, small, residual esotropia is encountered. The small deviations are often difficult to detect and may be overlooked because the eyes appear to be straight. Careful monocular covering is needed to note a slight jump of the deviated eye when the dominant eye is covered. This procedure is not easy when the patient is a small child who is inattentive and will not fixate steadily. But, if possible, it is helpful to detect such small deviations by observation of normal, everyday seeing habits rather than by the use of an instrument. It is so important in the young patient because of the uncertainty of subjective responses. Diagnosis may be made or confirmed with the aid of major

amblyoscope, afterimage test, or diplopia test. Personally, I use the afterimage test more and more.

In small angle esotropia, the stimulated retinal area possesses greater visual acuity and the image is clearer. Thus the diplopia is more annoying, since the images are closer together. The suppression must then be intense to overcome diplopia, and if anomalous retinal correspondence develops, it becomes strongly established.

Among the small angle esotropias is the partially accommodative esotropia. A full correction is given, and when the patient returns for re-examination his strabismus is much improved but his eyes are not quite straight. Complete cycloplegia is essential to relax the accommodation. Whenever the opportunity presents, full cycloplegic refraction with the use of atropine should be obtained, although some ophthalmologists are not convinced of its value. Oftentimes, the additional +0.50 or +1.00 diopter sphere that will be found may mean the difference between esophoria and esotropia. Failure to use this aid early in the examination is a definite handicap to successful treatment of esotropia.

Some patients who have been wearing a full correction are found, on rechecking, to be orthophoric or esophoric for distance vision but to have esotropia for near vision. Some of these patients do well when given a bifocal correction. Others will respond well to atropine used about twice a week. Patients with these conditions who have some fusion will often enlarge their fusional amplitudes with orthoptic training.

Other patients have residual esotropia after surgical procedures. The patient who has not had any preoperative training cannot be expected to overcome a small deviation and to obtain fusion. Sometimes a series of training periods immediately after operation may bring good results.

Theoretically, anyone should be able to overcome 4 or 5 diopters of deviation, but some patients cannot do so. They may even have some fusion, but their amplitude may be limited and rigid.

A review of cases of small esotropia in which follow-up studies have been made showed that the main obstacle seemed to be the difficulty in maintaining good visual acuity in the nondominant eye. In one case, a child, 7 years of age, had total occlusion for six months and partial occlusion for six months. The vision was 20/30 on the right and 20/20 on the left. After six months without occlusion, the vision dropped to 20/100. Occlusion was resumed, and after the child was 9 years of age the vision became stabilized at 20/40 and has remained so without occlusion for the four years that follow-up study has been carried out. This patient had esotropia of 8 diopters for distance and of 20 diopters for near vision with a small angle of anomaly. She had not been available for any orthoptic training, but her appearance is satisfactory.

Treatment is limited when the patient can be seen only periodically. It is discouraging to have a recurrence of amblyopia after occlusion has been stopped, but if we persevere long enough, we have found that many of these patients maintain fairly good vision of 20/40 or 20/30 without further occlusion. It is often necessary to keep up intermittent occlusion until the child is 10 or 11 years of age. It is my opinion that in these cases we must be content with good visual acuity in each eye and cosmetically straight eyes.

III

Miss Lucas

A LIMITED SURVEY OF SMALL ANGLE ESOTROPIAS (15 CASES)

When I accepted the invitation to appear on the panel to discuss small angle esotropias, it was with apologies for having so little success to report on the orthoptic treatment of these cases. However, not

until I had systematically surveyed a sampling of these cases did I fully realize just how ineffectual the orthoptic treatment had actually been.

In our office, diagnosis of small angle esotropia was made on the basis of objective and subjective tests, including (1) the cover test, to demonstrate any manifest deviation; (2) screen and prism measurements, to determine the maximum deviation; (3) diplopia tests, such as the Worth 4 dot and the red glass test, to indicate binocularity or lack of it; and (4) the afterimage test, to differentiate between true fusion responses and those attributable to anomalous harmonious retinal correspondence. Cases in which the esotropia measured five degrees (ten prism diopters) or less *with* correction on screen and prism readings were classified as small angle esotropia, regardless of the size of the angle without correction.

This report concerns 15 patients with small angle esotropia. Actual screen and prism measurements on these patients immediately before orthoptic treatment was begun revealed angles between one and ten or twelve diopters for distance and from five to ten or twelve diopters for near with correction; without correction the angles of squint varied from six to forty diopters for distance and from six to forty-five diopters for near.

Age of the patients at the time of orthoptic training varied from five to fourteen years; only four of the group were younger than seven. Consequently, the patients' powers of comprehension and concentration were adequate, and orthoptic failure could not be blamed on immaturity or lack of cooperation.

The number of exercises in a series ranged from six to twenty-four, depending on the amount of progress being made, and on the individual patient's psychological and emotional reactions to the treatment.

The exercises, of a standard nature, were prescribed with three major goals in mind: (1) to break down suppression; (2) to develop and stabilize fusion at the angle of deviation; and (3) to build fusion amplitude.

For achievement of the first goal, antisuppression exercises off the major amblyoscope consisted of (1) tracing and connecting dots, using a red lead pencil, with a red filter over the dominant eye; (2) stringing red and white seed beads, again with the red filter over the dominant eye; (3) recognizing diplopia and voluntarily alternating on lights and small white targets with, and later without, the aid of a red filter; (4) tracing simple pictures on the cheiroscope; and (5) when possible, achieving physiologic diplopia with framing exercises.

On the major amblyoscope, attempts were made to break down central suppression by means of familiar procedures including (1) the Sheila Mayou and Frances Walraven techniques, employing macular and foveal targets for fixation; and (2) chasing and break-and-join exercises, also with macular-sized targets for fixation.

For achievement of the second goal, developing and stabilizing fusion at the objective angle, exercises off the amblyoscope consisted of fusion at the near point, or at far and/or near settings if possible, using a red filter and light. Maintenance of fusion was striven for as the patient or orthoptist counted slowly, the patient remaining motionless and the light stationary until the images began to separate. On the troposcope, steadying of superimposition and second grade fusion at the objective angle was encouraged by similar techniques, care being taken that the initial targets were of a minimum degree of difficulty, i.e., fairly large, and clear, with "clearance space" so that the smaller fixation target might move about a little without coming out of the larger target into which it fitted.

Increase of amplitude, the third goal, was attempted off the major amblyoscope by systematically increasing the distance

from a light which had been fused at the near point, or by decreasing the distance from a light fused at the far point. The stereoscope, with slideholder set at infinity, was used in the case of older children whose answers could be considered reliable; targets gradually increasing in separation were inserted to effect divergence. On the amblyoscope, divergence was practiced with targets of a size feasible for the patient, i.e., the smallest size with which neither suppression nor diplopia occurred.

Throughout the exercises, the usual aids to divergence were suggested: looking up and off at a distance, slowly returning the gaze to the fixation targets, and relaxation of visual attention with no effort to discriminate small details.

Of course, not all of the above-mentioned procedures were followed with each patient, inasmuch as some patients were unable to progress beyond the simplest exercises and others were inconsistent in their performance of the exercises.

Of the fifteen patients included in this survey, not a single one developed spontaneous fusion as the result of orthoptic treatment. One fused postoperatively with the aid of full correction supplemented by bifocals, but the fusion was inconstant and sometimes questionable. Two or three others seemed to manifest some binocularity off the amblyoscope, claiming physiologic diplopia as well as fusion with some subjective tests although they still showed a small shift on the cover test.

The main area in which orthoptics proved of value in these cases lay in breaking down suppression. However, this apparent gain proved to be a mixed blessing for five of the patients who began to complain of diplopia in casual seeing. Three of these were particularly troubled by diplopia while reading, and had started to form the habit of automatically closing one eye to read. Two of the five patients could diverge to zero on the troposcope; two, to two diopters base-in; and one had no amplitude at all.

With regard to steadying fusion at the objective angle, two patients developed the ability to do so with macular-sized targets on the troposcope, and continued to demonstrate a very slight convergence ability thereafter.

In the other patients, amplitude training resulted in no improvement.

An analysis of data which might possibly be significant in the failure of orthoptic treatment to effect an improvement in these cases revealed the following factors:

1. Nine patients had previously been occluded for amblyopia; a slight residual amblyopia of one to four lines on the Snellen chart remained.
2. Two patients showed anomalous retinal correspondence, with definite subjective angles in the anomalous area.
3. Two patients showed incomitance in lateral gaze; one turned his head to the right when trying to fuse the images during exercises; the other reported a constant change of position of the images, in primary position.
4. One patient showed a vertical deviation of from three to eight prism diopters in the cardinal fields of gaze, with no incomitance on versions.
5. One patient was in poor health at the time of the exercises, suffering at various times from colds, a bronchial infection, an ear infection, and an attack of appendicitis.
6. One patient, who had had an initial amblyopia of 2/400, was unable to see similar images completely fused at any time, no matter how large the targets, at any angle.

Apparently, disappointment in the results of orthoptic treatment of small angle esotropia is not a unique experience. Lack of progress has been reported by others. Ruth Gittoes-Davies, a British teaching orthoptist, surveyed a group of eighty cases

which had come under her observation. In the British Orthoptic Journal, 1952, she reported that in her experience no real benefit had been derived from orthoptic treatment in such cases. It is her belief that many small angle esotropias, particularly those in which there is only a slight flicker of movement on the cover test, fall into the category of fixation disparities.

However, the characteristics of patients in Miss Gittoes-Davies' survey differed importantly from those of most patients included in this report. Each of the patients whom she included had demonstrated a good amplitude of fusion (at least ten degrees) plus stereopsis without any training whatsoever; obviously these factors reduced their need for orthoptic treatment. Also, on the cover test, a partial recovery movement of the nonpreferred eye after it had been covered and then uncovered was observed. Furthermore, physiological diplopia was appreciated by the great majority of the patients; those who did not claim it were too young for accurate reporting and observation.

Inasmuch as only one or two patients in our series can match Miss Gittoes-Davies' patients in binocular skills, the temptation to classify the majority of small angle esotropias as fixation disparities must be resisted.

Problems connected with small angle esotropias remain: Which cases should be referred for orthoptic treatment? How intensive and how prolonged shall treatment be before hope of functional result is abandoned? Are any changes which might be effected of sufficient magnitude and permanence to warrant prolonged and intensive treatment?

THE ORTHOPTIST'S APPROACH TO HER PATIENT

JUDITH MIDDLETON, O.T.
NANCY MALCOLM, O.T.
VANCOUVER, B. C., CANADA

THIS paper will be considerably different from those which have been presented concerning new techniques in diagnosis and treatment. It will deal with a subject which has, unfortunately, been sadly neglected; that is, the orthoptist's approach to her patient.

More is required of a technician than a solid knowledge of physiology and anatomy and the ability to make a correct diagnosis and conduct orthoptic treatment. She must realize that a patient is not "just a pair of eyes." He has fears, apprehensions and other emotions which have to be considered and evaluated along with his strabismus. Most important of all, an orthoptist has to have a real love for people and a desire to understand them; else, how can she happily apply herself to her chosen profession?

The orthoptist's relation to a child is very important. She must adapt herself to the child's personality; he must know that she is essentially his friend and that she honestly desires to help him. Time is not wasted in listening to a child's problem which may be completely unrelated to the visual one. If the patient confides in the orthoptist, it will follow that his confidence in her will grow, and he will become more pliable, in the orthoptic sense.

One cannot expect an immediately cooperative attitude from a child who is emotionally disturbed as a result of unstable and inconsistent responses from one or both parents. A few minutes spent apart from treatment with a difficult, hyperactive, six-year-old child supplies a respite (often a welcome one), and he and the technician return to work refreshed. You all know this type, I am sure: the wriggler, the sigher, the child who always tries to play with the machines and delights in turning switches off and on when one's back is turned, and who constantly demands "another picture."

Some of you will not agree with this approach. Perhaps you feel that no relaxation from routine should be permitted. However, we do not take the attitude of a disciplinarian. Instead, we try to meet the child on his own level and even, within reason, bend to his moods, which we must be quick to perceive. After all, a technician sees a child for only one-half hour a day. Can she expect to alter his behavior in that short space of time and still treat him orthoptically?

It must be realized that children live in a very limited world, with little or no understanding of the importance of binocular single vision. By intruding upon what they have accepted as a normal state and by making them aware and conscious of something that has been comfortably compensated for by the brain, you may be setting up a barrier of complete confusion. The strabismus must not be referred to as an abnormal condition but rather as a weakness or the result of a lazy eye. This approach, in most instances, produces an interest in awakening the eye.

Let me stress here that the technician does not permit her small patients to take advantage of her patience and good nature. A certain amount of firmness can be maintained, primarily by the tone of her voice, without losing any of the comradeship.

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Stars, stickers, candies, progress charts placed on the wall, and other rewards—all have value; but we would rather have the child return to us, not for the rewards, but because he is looking forward to his next treatment. Sincere praise for work well done or for good effort put forth is far more rewarding to most children; and the child leaves with a sense of accomplishment, excitedly telling his mother what good work he has done.

The orthoptist requires initiative and insight in her approach to any patient. For example, an uncomplicated convergence insufficiency in a child, apparently with no physiological disturbance, may be considered either hopeless or unsatisfactory after 12 treatments because of lack of effort or cooperation. In cases of this type a child is often heard to say "I can't pull my eyes in" or "I don't know what you mean," even after careful and thorough explanation and instruction. The child is repeating a behavior pattern. This is a cue for assurance and encouragement on the part of the orthoptist. Endless explanation only frustrates the patient, and the orthoptist becomes tired of repeating herself.

It is far more effective to show the child evidence of his efforts, as by teaching convergence (or increasing near point) with a light and ruler. With the ruler held on a horizontal plane alongside the nose, the light is gradually brought forward until diplopia is appreciated, then back and forward again, each time making note of the forward gain. Incidentally, this method can be used as a means of encouraging a very stubborn adult patient who, for some reason or another, cannot be improved on the synoptophore. Working without the machine, with no barrier between the technician and the patient, often proves more successful; the patient feels that this method is more reasonable than trying to see one picture on a target when there are really two pictures there all the time.

Another type of patient with convergence insufficiency which, after four to six treatments shows no sign of improvement in fusional range and no relief of symptoms, is the young woman between 25 and 35 years of age. She is usually well groomed and appears to be calm. The technician approaches her case in straightforward manner. The patient is unable to cope with home exercises and claims that they frustrate her. After subtle questioning, she reveals that she is quite tense and nervous under most circumstances. Once she has admitted this to the technician, the improvement in convergence is rapid. She is then told to do her home exercises every day, not at set intervals but rather when she feels calm and able to cope with them. Above all, she is told to stop her exercises as soon as they begin to upset her. At the time of the next treatment she reports that she has been able to do the exercises quite easily and that her symptoms are beginning to clear. All of this has resulted, not because the orthoptist has gotten to the root of the nervous tension, but because someone has taken just a little more than merely technical interest in her.

The serious, intelligent young man of eight years expects crisp efficiency from the lady in white. He is capable of comprehending what is the matter with his eyes and understands what he must do to correct the condition. He is interested in the surgery and understands why it is necessary, and he knows what the orthoptic aim is. His questions should be answered with as much straightforwardness and honesty as the orthoptist can wisely permit.

The shy little girl of five who must be almost pried away from her mother's skirts must be heaped with praise. Her dress, shoes, haircut and jewelry must be admired until her reserve is broken down; then the praise is carried into the orthoptic work. Praise gives her self-confidence, and the confidence gives her the desire to cooperate and put forth maximum effort.

Then, of course, there is the middle-aged matron who must be pampered to help her adjust to the new bifocals. This

is not an easy task. She has done a great deal for her family, and now that the family has grown up, she has too much time on her hands. With the realization of what she considers to have been years of self-denial, she turns to self-pity. She wants attention, and consciously or subconsciously tries to create situations which will demand sympathy and attention.

Above all, the orthoptist must know her limitations, but she should not use them as an excuse for avoiding her responsiblity, which is to make a careful analysis of each case from diagnosis to prognosis — from the start to the completion of the initial evaluation. When the initial evaluation appears inconclusive, excepting in those cases in which it is likely that orthoptics would be detrimental rather than beneficial, the patient should at least be given the benefit of the doubt and orthoptic treatment should be tried.

The aim, of course, is binocularity with comfort and control. To obtain this the orthoptist must be able to instill in the patient the desire for binocular single vision. The patient must have the desire and the orthoptist must have the cooperation of the patient. It is foolish to assume that merely by putting a patient behind the machine and following a set pattern with mechanical precision the orthoptist can obtain a cure.

To follow a set pattern for every case of one type may be theoretically correct, but orthoptically it is wrong. Each of the cases is unique even though similar symptoms occur. To know and to be capable of utilizing theoretical and practical orthoptics is essential; however, it is also necessary to combine with these an appreciation of the psychological factors in order to gain a completely satisfactory cure.

THE AMBLYOPIA TEST

GERALDINE ADAMS WOOD, O.T.
SEATTLE, WASHINGTON

THE subject of this paper is the test which was reported by Jaffe and Brock in the American Journal of Ophthalmology, August 1953, under the title, "Some Phenomena Associated with Amblyopia." We refer to this test simply as the "amblyopia test" and use our results with it to answer an important orthoptic question; that is, will occlusion, total or part-time, improve the vision of the amblyopic eye in any particular case? I shall discuss the test only from the viewpoint of an orthoptist using it daily as a diagnostic procedure.

The requisite equipment is a Bielschowsky afterimage tube and a tangent screen. In our clinic we use a blackboard instead of the tangent screen and find it quite satisfactory. The patient is seated four feet away from the afterimage tube, facing it. The tube is turned to the vertical position. An occluder is held over the amblyopic eye, and the other eye is stimulated for thirty seconds in a darkened room. With the occluder kept in place, the patient is asked to turn and look at the central target on the tangent screen, six feet away. He will notice a gray bar of light passing through the fixation point, vertically. Then the patient turns again to the afterimage tube and the nonamblyopic eye is again stimulated in the same manner. It is important to remember that the nonamblyopic eye is stimulated both times. Actually, the first stimulation is done only as a demonstration to the patient. However, after the second stimulation the patient changes the occluder to the other eye so that he fixes the other target on the screen with the amblyopic eye.

Does he see a vertical bar of light on the screen? Does it pass through the central point, as before, or does it now lie to the right or to the left of the target? At this time the patient must be cautioned to maintain fixation on the target as patients often look to the left or right, trying to locate the afterimage. The orthoptist should record the position of the bar and also whether it remains stationary or moves back and forth toward the fixation point.

There are three possible results of this test:

1. The image does pass through the target when the patient is fixing with the amblyopic eye. This indicates that the patient's vision will improve with occlusion, regardless of his age, the depth of his amblyopia, and his age at onset of strabismus. We call this a "positive result."

2. The image lies steadily at a point to the right or to the left of the fixation point when the patient is fixing with the amblyopic eye. This indicates that, regardless of how long or how well occlusion is carried out, the patient's vision will not improve. We refer to this as a "negative result."

3. The image wavers back and forth between the fixation target and a point to the left or to the right. This indicates that the vision of the amblyopic eye may respond to occlusion but possibly will not improve to the point where it is equal to that of the other eye. We call this a "fluctuating result." In this case, other considerations, such as the presence of binocular vision and the age and attitude of the patient, must be taken into consideration before deciding upon occlusion. (I have had only one patient with a "fluctuating result" in the past year and a half, and occlusion was not started because of the attitude of the parents.)

If a negative result is obtained, it may be possible to demonstrate the presence of an absolute or relative central scotoma about the fovea, but we do not as a rule require this further demonstration.

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Unfortunately this test cannot be used in all patients with amblyopia. Those with abnormal retinal correspondence are excluded for the following reason: When the fovea of the nonamblyopic eye is stimulated, the corresponding point in the other eye is also stimulated and can therefore appreciate the transferred image; if abnormal retinal correspondence is present, the corresponding nonfoveal point in the amblyopic eye is stimulated. Therefore, when the central target is fixed with the fovea of the amblyopic eye, the afterimage will be displaced in proportion to the angle of anomaly. Of course, this result is not of value in indicating the prognosis for the improvement of visual acuity.

There is, however, one other way in which we have used this test several times. In each of two patients with alternate suppression who were not responding to treatment, we stimulated one eye but were never able to elicit an afterimage response in the other eye. Another patient, sent to us for preoperative evaluation, was an adult who said that the onset of her exotropia occurred when she was 7 years of age. Her visual acuity in the two eyes was equal, with alternate suppression. However, she claimed that with stimulation on the troposcope, she had momentary fusion. This finding was questionable. Therefore, we stimulated one eye with a vertical afterimage several times, but the patient could not appreciate a transferred image. Because of these results, we feel that there is a good possibility that this test can be used as a method for distinguishing between patients with only alternate suppression and patients without any retinal correspondence commonly called "true alternators."

Of course, the amblyopia test is most useful in cases in which the age of the patient is between 8 and 15 years. At this age, occlusion is a real handicap, but we have found that when we could state to the parents and the patient that his vision would definitely improve, we have always received their willing cooperation. The test is also invaluable in instances in which occlusion has been carried out for several months without any improvement in vision. If the result of the test was positive, the orthoptist will not hesitate to continue the treatment and sincerely encourage the patient and parents and, if necessary, the doctor.

During the past ten months we have used the amblyopia test in more than fifteen cases. I will just note a few of them:

Beverly B., 7 years old, was 2 years old at the onset of strabismus. The result of the amblyopia test was positive. Her vision was 20/100. She was treated with occlusion for four and one-half months without improvement. However, we persisted in the treatment, and in the sixth month the vision increased to 20/50.

Peter H., 11 years old, was 6 years old at the onset of strabismus. The result of the amblyopia test was positive. Peter's vision was 20/50, and in one and a half months it was improved by occlusion to 20/25.

Billy M., 12 years old, was 7 months old at the onset of strabismus. The result of the amblyopia test was negative. He had been treated by occlusion for five months at the age of 5 years without any improvement.

Billy L., is 12 years old. The date of onset of strabismus remains questionable. The result of the amblyopia test was positive. After four months of total occlusion, his vision increased from 20/40 to 20/20.

Mr. G., 30 years old, was 5 years old at the onset of strabismus. The result of the amblyopia test was positive. At the time he was sent to us for preoperative evaluation, he had already been treated by occlusion for one month on a part-time schedule, and vision had improved from 20/70 to 20/50. He was experiencing considerable diplopia, and as no sign of fusion could be elicited, occlusion was discontinued.

We have gone to considerable lengths to describe the test to the doctors in Seattle and to discuss the evaluation of the results. Now we can use it as a standard test at the time of the first visit and note the result in our initial report to the doctor.

Of course, as with all tests used in children, there is always some question as to the subjective response. For this reason

we make a practice of repeating the test during several visits to verify our results, but we have usually found this method to be simple enough to avoid confusion on the part of the patient. Therefore, from our personal experience, we strongly recommend the routine use of the amblyopia test in orthoptic clinics.

ETIOLOGY AND MANAGEMENT OF CONVERGENCE INSUFFICIENCY

CHARLES E. DAVIES, M.D.
VANCOUVER, B. C., CANADA

The practice of ophthalmology has undergone tremendous changes in the past fifty years. Radical changes in the medical and surgical treatment of ocular disease have been accompanied by a vast increase in our knowledge of optics and of the etiology and management of muscular imbalances.

Just as the introduction of sulfonamides in the early thirties and of penicillin ten years later revolutionized the treatment of acute infections, so orthoptics in its present form has changed the treatment of various forms of muscular anomalies. Furthermore, as the sulfonamides and the antibiotics have not eliminated infections, so orthoptics has not cured or eliminated all muscular imbalances. Only by a review of treated cases and a careful unbiased analysis of available statistics are we able to come to a reasonable evaluation of orthoptics.

In my private practice I have found that orthoptics is becoming increasingly more important to me, not only in the preoperative and postoperative management of patients with strabismus but, more important still, in the treatment of patients with convergence insufficiency. To orthoptists the term does not require further explanation.

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I am indebted to Mrs. Maddox Yates for her explanation of the breakdown which occurs in convergence insufficiency. This explanation, in my opinion, has stood the clinical test for the past ten years and seems to be a logical approach.

Convergence is governed by autonomic reflexes, subvoluntary movements which are linked with accommodation, and voluntary movements. The lines of demarcation are not exact and flow one into the other. The autonomic and subvoluntary movements are not dependent upon conscious effort. In convergence insufficiency, voluntary movements become necessary for convergence, and it is at this point that the patient experiences definite subjective symptoms. The ability to converge is still present, but only with conscious effort. During the first few minutes of reading or close work no apparent effort is necessary, but continuous application to close work brings on the symptoms of which you all are aware.

We all have had experience with the employee who works under improper lighting, the commercial artist who works with glazed paper, the watchmaker or the person who uses a monocular microscope and develops dissociation, and the patient with a toxic goiter, cerebral tumor, myasthenia gravis, or cerebral trauma.

We have had a number of patients with cerebral trauma who had marked symptoms of convergence insufficiency. Malingering could be excluded as a factor in these cases. The restoration to normal autonomic control was very slow, requiring weeks of treatment. The Workmen's Compensation Board now recognizes convergence insufficiency as a definite entity, largely, I think, because of the excellent results in treatment which we have been able to achieve.

Tests for convergence insufficiency are many and varied, but they all involve one basic factor. What is the fatigue point; how quickly is it reached; and is suppression present? We must not underestimate the importance of suppression, whether it be foveal, macular or paramacular. The rapidity with which it is eliminated depends on the method used and the intensity of the suppression. It is impractical for an ophthalmologist to instruct a patient in how to overcome suppression and then to check up on him to see whether he is doing his exercises, and whether he is doing them correctly. It is in this work that an orthoptist is most valuable.

In cases in which there is no suppression, the improvement in the ductions can be accomplished by home exercises. The patient is usually asked to come to the office for a check on his progress at regular intervals.

In the ophthalmologist's office, convergence insufficiency can be quickly and accurately determined by asking the patient to fix his eyes on an object, such as a pencil, which is moved back and forth rapidly at a distance of from 16 to 20 inches in the primary position and then is gradually brought toward the eye. Usually the eyes will converge on the pencil and then lose fixation and diverge. If the patient sees double, no suppression is present. I have found this test to be most useful and accurate in about 90 per cent of the cases, as established by the orthoptist's report.

There are various types of convergence insufficiency. Some patients have high adduction with low recovery. They usually respond well to orthoptic training, consisting of from five to seven office treatments followed by home exercises. Patients with low adduction and low recovery almost invariably have suppression. These usually have convergence deficiency of long standing, and their recovery is slow. The patients who have the most difficulty are those who have an exophoria at near and a low abduction power, often with hyperphoria and usually with suppression. Patients in the latter group get little or no relief from orthoptics. Their ductions seldom improve in spite of a prolonged series of exercises. I shall refer to this group again.

The next question to arise is "How are we to determine when a patient has recovered from convergence insufficiency?" First, he gets symptomatic relief—fewer headaches and less reading strain. He wears his glasses with greater comfort. His ability to concentrate has improved, and his photophobia, which usually has been very marked, is decreased or even totally eliminated. The individual with early presbyopia will soon find that he can wear his proper correction with ease.

The objective signs of recovery from convergence insufficiency are less startling, and it is sometimes difficult to correlate the findings on the troposcope with the subjective symptoms. When results are ideal, the patient rapidly gains normal ductions and recovery point. There are some patients, however, whose recovery point seldom improves past 20 diopters but whose discomfort is relieved. In my experience, it is in these cases that additional strain and stress produce a breakdown of the improved function so that the patient returns after a short while, complaining of his original discomfort. We have found, over the past six years, that a patient whose recovery point can be brought up to 60 diopters and over and

who continues home exercises for several months is not likely to require further treatment.

I should like to speak now of the attitude of the orthoptist toward the patient. Orthoptic treatment requires the practice of diplomacy by both the ophthalmologist and the orthoptist. First, it is the prime duty of the ophthalmologist to explain to the patient his condition. Convergence insufficiency is not so much a question of weak eye muscles as a breakdown of the normal reflex action in those centers in the brain which control convergence and accommodation. This control must be restored before the patient can hope to have relief from his discomfort. This explanation prepares the patient for treatment; he realizes that the rapidity of his improvement is to a large extent dependent upon his willingness to cooperate and concentrate on the work which the orthoptist supervises. The orthoptist, on the other hand, must be able to inspire the patient's confidence in the work to be performed; she must be able to explain in a logical way the various steps necessary for his recovery. If the orthoptist handles the problem in a haphazard way, the patient quickly loses confidence and readily finds an excuse for not returning for treatment.

Allow me to digress here and give my own views about the work of the orthoptists in orthoptic clinics as compared to the work of the orthoptist in an ophthalmologist's office, as a member of his staff. In the orthoptic clinic there is a tendency toward mass production, for there are many ophthalmologists to satisfy. At times the technicians are forced to accept more cases than they can handle, at the expense of individual supervision. On the other hand, the orthoptist who works in the office of one or more ophthalmologists is better able to schedule her appointments and give adequate attention to the individual patient, which I consider to be essential. I have had experience with both arrangements, and the results demonstrate the wisdom of the latter. This arrangement, I confess, is not as remunerative as the alternative. I should be much better off financially if I sent my patients to an orthoptic clinic, but I consider orthoptics to be an integral part of my practice, not only for the satisfaction of the patients but also for convenience of operation. I feel that these differences more than compensate for any financial loss. When one is balancing the ledger, he must consider the extra help which a good orthoptist can give in doing fields and in helping in the outer office when one of the other girls is away on holidays or is ill.

I now come to the last and most discouraging type of convergence insufficiency, which I mentioned earlier. The patient who has an exophoria at near and a low abduction power, often with hyperphoria and usually with suppression, gains little or no relief from prolonged treatments and may even find that orthoptics increases his discomfort. Some of you may have a satisfactory solution to this problem. If you have, I should be most grateful for your help. In any event, a complete survey of the patient's eye condition should be made, starting with a complete and careful history. A complete physical examination, including roentgenograms of the teeth and sinuses to reveal possible foci of infection, should be made by a competent internist. A review of the patient's refraction and orthoptic chart is also necessary.

In cases in which it is found impossible to improve the convergence recovery point, there is a proportional decrease in accommodation. The symptoms accompanying this are very marked, and although the patient may have 20/20 vision without correction, he complains that he has been unable to use his eyes for close work even for periods of from ten to fifteen minutes. He readily becomes exhausted if he is in a crowd for any length of time; shopping is a nightmare; enjoying television and

motion pictures is impossible. Glare of any kind brings on an acute exacerbation of his discomfort which may leave him exhausted for a day.

This type of convergence insufficiency is a real entity and cannot be confused with malingering or general physical weakness. In my experience, most patients with this condition are above normal in general physical powers and mental alertness. These patients really need help and every effort must be made to make their disability as easy to bear as possible. The space eikonometer may show a difference in the size of the images of the two eyes, and the proper fitting of aniseikonic lenses may give a tremendous amount of relief in many of the most stubborn cases. Occasionally, a recession of the lateral rectus has given relief when an exophoria for distance has been persistent.

I have left many things unanswered, and I have only touched the rim of possibilities in management. It is to you who are continually working with these patients that the final answer must come. If I have stimulated you to a closer and more critical analysis of your cases, I have indeed served in a small way to advance the importance of orthoptics as an integral branch of ophthalmology.

SUPERIOR OBLIQUE TENDON SHEATH SYNDROME REPORT OF A CASE

EVERETT F. RAYNOR, M.D.
VANCOUVER, B.C., CANADA

WE are all familiar with various forms of congenital fibrosis syndromes such as Duane's retraction syndrome, strabismus fixus, and generalized fibrosis. Less familiar is the superior oblique tendon sheath syndrome described in 1950 by Brown.[1] The features of this syndrome are as follows: There is a slight backward tilting of the head and no deviation of the eyes with the head in this position. There is an apparent paralysis of the inferior oblique of the affected eye. When the affected eye is led into adduction it drops below the horizontal and there is a widening of the palpebral fissure. The affected eye cannot be elevated in adduction nor can it be elevated directly upwards, and there is a widening of the palpebral aperture on attempting either position. There is normal range of movement in all other directions of gaze, and there is no evidence of any contracture of the homolateral superior oblique. In bilateral cases the backward head tilt may create an impression of bilateral ptosis. When the patient is asked to elevate his eyes rapidly or to follow a light that is rapidly raised, the affected eye comes to an abrupt halt below the horizontal. This is most evident when the affected eye is adducted. When an attempt is made to elevate the adducted eye with forceps, a distinct resistance is felt.

As Brown pointed out, there is in these cases a short superior oblique tendon sheath that prevents the eye from being elevated in the adducted position. Because of this abnormal check ligament, contraction of the inferior oblique is ineffective in elevating the eye. When the superior oblique tendon sheath is severed, the eye can then be elevated with forceps and no resistance is felt. After the operation there is a variable amount of recovery of action of the inferior oblique, from no improvement to moderate improvement. In none of Brown's cases was there full recovery of action of the inferior oblique after surgery.

Many cases of this syndrome have probably gone unrecognized in the past, and either the patient has received no treatment or the inferior oblique has been shortened and no improvement obtained. Although this condition is uncommon, it was thought that the report of a case would be of value.

CASE REPORT

No. 168033, L. C., a boy 3 years of age, was first seen at the Eye Clinic, Health Centre for Children, on July 7, 1954. His mother stated that he had had a squint since birth. The family history was negative for squint, and he had four brothers with normal eyes. Examination showed a negligible refractive error under cycloplegia, and the visual acuity could not be determined. The eyes were fairly straight in the primary position (fig. 1). When the gaze was directed up, and up and left, the widening of the palpebral fissure was evident, but the right eye could not be elevated directly upwards above the horizontal. When the attempt was made to look up and left, the right eye turned in and down. The eyes were parallel in all other directions of gaze and there was no overaction of the right superior oblique when the gaze was directed down and left.

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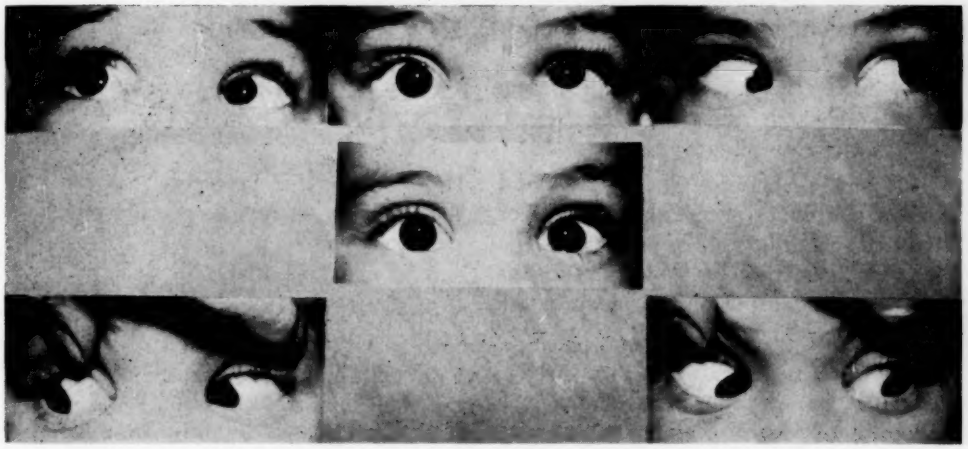

FIG. 1.— Eyes in various positions of gaze before surgery.

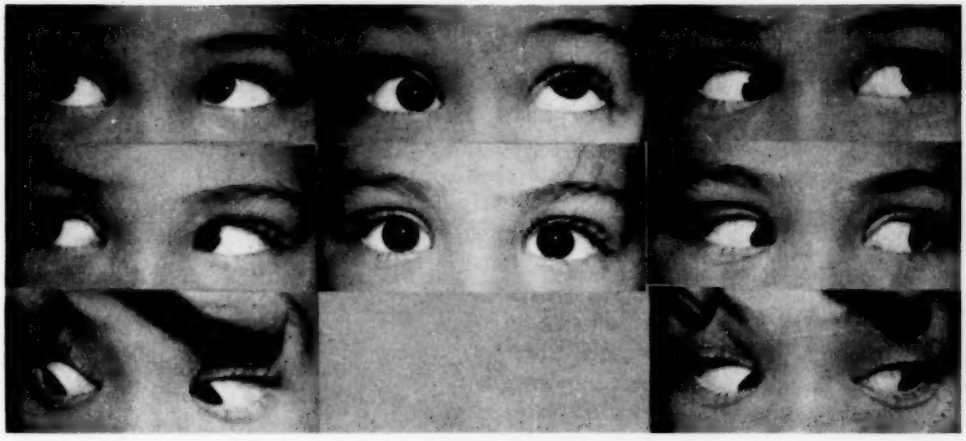

FIG. 2.— Eyes in various positions of gaze after surgery.

On October 7, 1954, with the patient under general anesthesia, an attempt was made to move the right eye up and in with forceps, but definite resistance was encountered. The superior oblique tendon sheath was then exposed and severed, but the superior oblique tendon was left intact. After this procedure, the right eye could be turned up and in with forceps with no resistance. As of April 5, 1955, it was evident that the right eye could not be elevated up and in, but it could be elevated above the horizontal, and there was very little widening of the palpebral fissure in any direction of gaze (fig. 2).

SUMMARY

A case of superior oblique tendon sheath syndrome showing improvement after surgery has been presented. One cannot draw conclusions from a single case, but it is felt that the earlier these patients are operated upon, the better will be the results.

REFERENCE

1. Brown, H. W.: Superior oblique tendon sheath syndrome. In Strabismus-Ophthalmic Symposium, St. Louis, C. V. Mosby Co., 1950.

SURGERY FOR STRABISMUS

DEREK G. SIMPSON, M.D., F.R.C.S. (ENG. & EDIN.)
VANCOUVER, B. C., CANADA

The aim of surgical intervention in cases of strabismus is to either weaken or strengthen the action of muscles. The variations in method by which this aim is achieved are almost as numerous as are the surgeons who do it.

The intricate details of the surgical technique are not the concern of the orthoptist. In general, actions are strengthened by tucking, resecting or advancing muscles; whereas actions are weakened by recessing or tenotomizing the insertions.

The most difficult and the most important problems for the surgeon arise before the operation is undertaken. He must answer the questions: Whether? When? What? How much? and How good? In other words, he must consider the indications, timing, principles, technique and prognosis. Orthoptics may be an important factor in each of these considerations. In most cases of strabismus, preoperative and postoperative exercises are a valuable adjunct to surgery.

INDICATIONS

Whether to Operate?

The following factors suggest the desirability of surgical intervention.

1. Constant or large squint in babies. Early operation reduces tendency to perverted reflexes.

2. Binocular vision in older children which cannot be sustained without training devices.

3. Disfiguring deformities or secondary deformities such as torticollis.

4. Squint which has resulted in psychological and social problems as a result of the patient's attitude, especially when the patient's distress is aggravated by the reactions of his associates.

5. Vertical deviations, even when small, as they do not respond well to orthoptics. Similarly, combined horizontal and vertical errors usually require surgery.

6. Incomitance resulting from bands or contracture of a muscle.

7. Eye strain and/or blurring of vision caused by the patient's efforts to hold the eyes straight, as sometimes occurs when small angle squint has been partly overcome by orthoptics and glasses.

TIMING

When to Operate?

In children under four years of age, whose angle of deviation is constant, and particularly when it is large, the operation should be performed without undue delay if the general health of the patient permits. Squint in babies contributes to the firm establishment of faulty vision habits. When these babies reach 4 years of age, orthoptics should be employed, and if necessary, further surgery should be done.

In children of an age (4-14 years) at which effective orthoptics can be used, the operation should be done as soon as the eyes have been taught to work together. Cultivation of proper binocular reflexes by orthoptics should continue as soon as practicable after the operation.

In older children and adults there is little likelihood that the operation will improve function. However, it is highly desirable that the appearance of these patients be improved. The operation may be done at any convenient time.

Read at the Western Regional Meeting, American Association of Orthoptic Technicians, Vancouver, B. C., Canada, May 13-14, 1955.

PRINCIPLES

What to Do?

The general aim is to adjust muscle actions to permit better function. There are a great variety of satisfactory procedures. Consider a case of convergent squint. Theoretically, the surgeon may move any one of the four horizontal muscles, move any pair of the four horizontal muscles, move any three of the four horizontal muscles, or move all four of the horizontal muscles. These combinations provide a total of 17 choices. No wonder the orthoptist may observe several procedures for similar conditions!

The preoperative orthoptic assessment and treatment are helpful to the surgeon in determining which muscles to alter. He usually endeavors to strengthen the action of the weak muscles and to reduce the power of the antagonists. In cases of complicated squint, two or more operative stages may be planned, allowing intervals of at least three months for the full effect of each procedure to be appreciated. The amount of correction obtained becomes slightly reduced during the first few weeks after the operation. Hence a slight overcorrection immediately postoperatively is desirable.

TECHNIQUES

How Much to Do?

This decision depends largely on the surgeon's experience. Correction of large angles of deviation usually require movement of two or more muscles; whereas in small angle deviations, movement of one muscle may be sufficient.

In patients with squint of recent onset and in babies, no secondary contractures have formed. Operations have greater effect in these patients and care should be taken to err on the side of undercorrection.

In uniocular squint, it is popular to operate on the muscles of one eye—the deviating eye. Alteration of the medial rectus produces a greater effect than a similar procedure on the lateral rectus. Furthermore, the change in the angle of squint obtained by operating on both muscles at the same time is greater than would be surmised by adding the effects of operations on each muscle singly. If the angle of deviation is large, one or two muscles of the other eye may require operation. The surgeon may elect to do this as a second stage of the operation.

Bilateral operations on medial recti are favored by some surgeons, particularly when convergence excess is present, in order to weaken convergence power. In divergence deficiency, the rationale for bilateral operations on the external recti is a desire to strengthen the weak actions.

Alternating squint is considered by some surgeons as an indication for bilateral muscle surgery.

When both horizontal and vertical deviations are present, it may be wise to operate in two stages. If the vertical error is large, it is best to correct it first.

In vertical squint, the surgeon may elect to strengthen the weak action and/or weaken the strong action. His decision may be modified by the following considerations:

1. Action of the superior oblique is difficult to alter by surgery. It is preferable to operate on the antagonist or yoke muscle if satisfactory results from this procedure can be anticipated.
2. Inferior rectus action is highly important since most of our activities require looking down. Rather than to weaken the action of the inferior rectus, it may be wise to strengthen the action of the superior rectus.

In paralytic squint, tendon transplantation can provide a rather weak action. To attain control, considerable effort is necessary on the part of the patient to re-edu-

cate the muscles. This feeble action can be assisted by weakening the action of the antagonist, and binocular coordination can be helped by reducing the excessive action of the over-stimulated yoke muscle.

PROGNOSIS

How Good Are the Results?

Surgical correction can make the eyes approximately straight from the anatomical and cosmetic point of view. Functional perfection can be attained only when binocular reflexes are in good working condition or can be trained by orthoptics to operate efficiently.

A good surgical prognosis can be given except when the following factors are unresponsive to orthoptics:

1. Amblyopia
2. Abnormal retinal correspondence and false macula
3. Convergence weakness due to disuse, e.g., in the presence of amblyopia
4. Marked dominance of one eye, which favors recurrence of amblyopia, especially when associated with anisometropia

AMERICAN ORTHOPTIC JOURNAL

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Editorials

THE AMERICAN ORTHOPTIC JOURNAL

ITS FIRST LUSTRUM

The vitality of a professional group is not measured only by the individual achievements of each member. In a truly vital group each member must contribute to the over-all progress of the profession. It cannot be expected that every member make significant original contributions. But each member can and must to the best of his ability contribute to the storehouse of information and help in making this information available to all. Each member must from time to time take stock of the results of his work. Each member will naturally tend to concentrate more on one aspect of orthoptics than on others and thus acquire a wide range of experience in this particular aspect of the field. It is the duty of each member to communicate this experience to all other members and thus to disseminate the accumulated information.

There are two ways in which this can be achieved. Both ways are important and have their proper place. One is by attending meetings and contributing to their programs. At such meetings the exchange of views is often the most fruitful aspect of the gatherings. Nevertheless, the spoken word is fleeting. Only if the accumulated knowledge and experience is made permanent in print can it have a lasting effect. This has been recognized by the leaders in the orthoptic profession, and thanks to the far-sighted generosity of the American Academy of Ophthalmology and Otolaryngology and its Executive Secretary-

Treasurer, Dr. William L. Benedict, it has become possible to produce a permanent record in the form of the AMERICAN ORTHOPTIC JOURNAL.

The progress made since the first slim issue appeared in 1951 is well expressed in the remarkable increase in the number of papers appearing in each volume. The progress is constant and, we hope, will continue in the years to come. It is anticipated that future issues shall include not only papers read at regional and national meetings but also papers submitted directly for publication.

The AMERICAN ORTHOPTIC JOURNAL will remain a yardstick for the vitality and progressiveness of American orthoptics. It has been a privilege to be associated with it as editor for three years, and I look forward to great future advances under the able editorship of Dr. William E. Krewson, III. However, it must not be forgotten that the JOURNAL cannot be better than its contributors. The best editor cannot produce a worthy publication without the unstinting support of all concerned. In relinquishing the editorship to Dr. Krewson, I wish to thank all who have assisted me so wholeheartedly in the past three years and to solicit the same support for our new editor.

HERMANN M. BURIAN, M.D.

THE OLD AND THE NEW

With the passing of the year 1955, a change in the American Orthoptic Council has taken place which must not remain unnoted in these pages.

Dr. Frank D. Costenbader, who has carried the burden of the secretary-treasurership of the American Orthoptic Council since January 1, 1948, has been relieved of his duties at his request, and the Council has unanimously elected in his stead Dr. Edmond L. Cooper of Detroit.

Whoever had dealings with the Council during Dr. Costenbader's tenure of office —doctors, orthoptists and outsiders alike —had the opportunity to appreciate his efficiency, thoughtfulness and sincerity. But only those who were more closely associated with him in the work of the Council realize fully how much his wise judgment has contributed to orthoptics, and through it to American ophthalmology. His enthusiastic interest in the subject, his abilities as an organizer, his untiring efforts, added to a busy professional schedule, have contributed in large measure to making American orthoptics what it is today.

The members of the Council acceded with regret to Dr. Costenbader's decision to decline re-election to the secretary-treasurership, but they respected his wish to have some of his time freed to pursue other activities. Their regret was mitigated by the fact that the Council members felt that they had found a worthy successor to Dr. Costenbader. They are confident that Dr. Cooper will carry on the work of the Council with as much success in the future as Dr. Costenbader has in the past.

OPPORTUNITIES FOR PARTICIPATION

With some form of award for outstanding leadership and/or achievement in the American Association of Orthoptic Technicians currently under consideration, the subject of participation in activities outside the daily orthoptic routine has been brought to attention again. However, aside from this stimulus, there are other good reasons for more extensive and more active participation in such work.

In the first place, a real need exists for more enthusiastic committee members. As the AAOT grows, it becomes necessary for the sake of efficiency to divide the responsibilities associated with its function-

ing among a greater number of individuals; otherwise, the organization cannot serve its members maximally.

In both regional and national groups, contributions of time and ideas by the members are welcome. The several standing committees of the national organization and the more informal ones of the regional sections are continually in need of members with a willingness to serve and with the ability to organize and discharge duties which may be delegated to them. Furthermore, suggestions of possible speakers, topics for discussion, and anything else which might benefit the organization and its members are always in order.

As a result of the revision in rules governing the slide contest, a greater number of entrants in that type of activity can now be expected. With the elimination of the requirement that each contestant do all the work involved in the construction of the slide which she submits, those of us who may be brimming with ideas but lacking in artistry have an opportunity to submit the idea for a good slide and thus to compete on an equal basis with those who are more gifted artistically.

Along more scholarly lines, as a group and as individuals, we have a responsibility to share and increase the store of orthoptic knowledge. This can be done by preparing papers to be delivered orally at the regional or national meetings or to be submitted for publication in orthoptic or ophthalmologic journals. The subject matter may range from the presentation of a new theory or the description of a new technique to the suggestion of a helpful variation in a standard procedure or the description of some previously unnoticed characteristic in a given type of case. Relatively little research has been done in the field of orthoptics; work in this area might well lead to the uncovering of new bits of information which would result in more precise diagnosis and more effective treatment.

Even a little reflection makes it apparent that much is to be done outside the realm of routine orthoptic practice. The responsibility of doing a share of it rests with each of us.

LORRAINE LUCAS, O. T.

THE FUNCTION OF FIXATION IN THE DIAGNOSIS OF FUSION STATUS

Evaluation of fusion status is a primary function of orthoptics. The motor conditions which prevail while a patient reports on his subjective fusion affect perceptions. Fixation is the basis of motor fusion. Other motor factors control the location of each image, but fixation determines the sensory relationship of one image to the other; it provides the necessary opportunity for two images to be related in space.

If only one eye is fixing, there is no second image present for sensory evaluation. This is true whether fixation is limited to one eye only or is alternated between the two eyes. Fixation by first one eye and then the other results in the reception of two different images which have relationship in time. This cannot be fusion. The images must be perceived at the same time in order to have relationship in space. Such relationship may be normal or anomalous and may result either in disparity (diplopia) or in fusion, in which case the images are fused if they are similar or fitted together if they are unlike.

If a patient is permitted to alternate or even lose his monocular fixation while trying to interpret and report on his sensory fusion, the evidence collected is not spa-

tial relationship in binocular vision. He does not experience binocular vision in the presence of unstable fixation.

When the patient claims an anomalous relationship between two images, the diagnosis should include a statement about the conditions under which he is making sensory interpretation. Is he receiving two stable images which can have a relationship in space, or is he reporting on evidence collected from one eye at a time?

Patients who "have no fusion" may merely have such unstable fixation that they cannot relate two images at all. Other patients reporting anomalous relationship may also have only one image at a time.

This is a plea to include a determination of stability of fixation in all orthoptic diagnosis.

JULIA E. LANCASTER

THE AMERICAN ORTHOPTIC COUNCIL — 1956

The American Orthoptic Council is composed of three representatives each from the American Ophthalmological Society, the Section of Ophthalmology of the American Medical Association, the American Academy of Ophthalmology and Otolaryngology, and the American College of Surgeons. Four associate members are elected from the American Association of Orthoptic Technicians.

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The following abstracts were made possible by the Assistant Editors, Miss Ann T. Eustis and Miss Mary V. Stallworth, with the help of the following committee:

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CLASSIFICATION

1. Accommodation
2. Amblyopia
3. Anomalous retinal correspondence
4. Diplopia
5. Divergent deviations
6. Esotropia
7. Fusion
8. Instruments and devices
9. Miscellaneous
10. Paralysis
11. Physiology
12. Refractive error
13. Stereopsis
14. Surgery
15. Torsion
16. Vergences
17. Vertical deviations
18. Vision

1-1

Burian, Hermann M. and Allen, Lee: *Mechanical changes during accommodation observed by gonioscopy,* A.M.A. Arch. Ophth., 54:66-72 (July) 1955.

The authors used gonioscopic devices and slit lamp illumination to observe the mechanical changes taking place in the normal eye during active accommodation and during relaxation of accommodation. Their subjects were twenty randomly selected routine refraction patients between the ages of fifteen and twenty-six years. This age group was chosen because the eyes are then fully developed and the accommodation still quite active.

The report includes observations made of the pupil, iris, ciliary body bands, scleral spur, lens, trabecular zone, and ring of Schwalbe. The classical changes in iris and lens position, and in volume distribution inside the anterior chamber, were pronounced. Relaxation of tension of the zonules and of the vitreous body seemed to occur.

Some new observations were particularly interesting. One concerned an apparent change in color and texture of the trabecular zone when accommodation took place. The other concerned the periphery of the lens, in which a more acute angle was seen between the central and peripheral part of the capsule during accommodation. Also, an optically empty space was noted in the region of the canal of Petit during accommodation.

All observations made by the authors were in agreement with the Helmholtz theory of accommodation.

2-1

Urist, Martin J.: *Eccentric fixation in amblyopia exanopsia,* A.M.A. Arch. Ophth., 54:345-350 (Sept.) 1955.

This paper presents a study of 98 patients with eccentric fixation examined at the Motility Clinic of the Illinois Eye and Ear Infirmary. In the 58 cases in which treatment by occlusion was instituted, the eccentric pattern was firmly established, there being no roving or searching movement of the affected eye when the sound eye was covered during examination. All of the patients in whom vision could be tested showed an acuity of less than 20/200 in the amblyopic eye. Seventy per cent had an acuity of less than 5/200 in the eccentric eye.

Investigation of the refractive status revealed that the eccentric eye had a larger refractive error than the sound eye in approximately sixty per cent of the cases; the sound eye had the greater error in eighteen per cent of the cases. The occurrence of eccentric fixation was found to be twice as frequent in the left eye as in the right. The author raises the question of whether this might be due to the fact that the right eye is ordinarily the dominant one.

Occlusion of the sound eye was carried out in all 58 cases, on a twenty-four-hours-a-day

basis, for at least six months unless the fixation ability and vision became equal before that. Six months was the minimum trial period in cases showing no improvement. Occlusion was continued as long as a year and a half if steady improvement was being shown throughout that time.

On the whole, the results of the study were encouraging. All of the children in whom occlusion was begun before the age of four attained normal vision in the formerly eccentric eye, and several cases in the eight-to-twelve-years age group showed an equally good response. However, the author warns of the difficulty in maintaining proper occlusion at the older age level, due to the fact that the vision which a younger child finds adequate proves grossly inadequate for the visual tasks required of the older child. Therefore, the latter does not tolerate well the lower vision forced upon him during the initial period of occlusion.

From this study, the author was led to conclude that the age at which occlusion was begun was of more importance than the age at onset of the squint. Although his findings do not appear to agree with Chavasse's theory of amblyopia of arrest, he points out a possibility of reconciliation through his proposal that a squint originally alternating, permitting the development of good vision in each eye, may later become monocular with the passage of time. Subsequent amblyopia might then understandably be successfully treated by occlusion.

3-1

Bedrossian, E. Howard: *Anomalous retinal correspondence in alternating strabismus,* A.M.A. Arch. Ophth., 52-669-682 (Nov.) 1954.

A refutation of the commonly held belief that anomalous retinal correspondence occurs only rarely in cases of alternating strabismus is presented in this article. The origins of the belief are traced to conflicting ideas on the etiology and development of anomalous correspondence, to differences in definition and classification, and to lack of uniformity in testing methods.

To the author, anomalous retinal correspondence is retinal correspondence in which the two foveas have lost their common visual direction. Whether or not actual superimposition of dissimilar targets is claimed at an anomalous angle on the major amblyoscope is not considered vital; consequently, the many cases in which there is suppression and/or crossing of images at a subjective angle setting significantly less than the objective angle may be included under this definition.

The author's interest in the state of retinal correspondence in patients with alternating strabismus was aroused by the number of poor results which he obtained despite good surgical procedures and apparent cosmetic corrections upon immediate postoperative examination, and by the relatively high incidence of postoperative (and paradoxical) diplopia. Cases in which the visual acuity of the two eyes was equal, or within two lines of equality, on the Snellen chart were considered alternating.

Synoptophore tests, and afterimage tests when maturity permitted, were used to determine correspondence. Diplopia and Lancaster red-green tests were also employed in some instances, especially when doubt existed as to the type of correspondence.

Of the seventy-six patients whose cases of alternating strabismus were reviewed, fifty-three had surgery; of these, forty-two were followed postoperatively for a period of one year or longer. Only five patients were given supplementary nonsurgical treatment: one, preoperative orthoptics; and four, postoperative occlusion. Forty-one of the seventy-six patients showed anomalous correspondence, the incidence being relatively high (sixty-four per cent) in esotropias developing before the age of three and relatively low (twenty per cent) in esotropias developing after the age of three.

Surgical results seemed to vary directly with the type of preoperative correspondence. Of the patients with normal retinal correspondence, ninety-six obtained and maintained straight eyes. Of those with anomalous correspondence, sixty-one per cent obtained a good result; the remaining thirty-nine per cent reverted to the preoperative angle of squint in whole or in part, and required ". . . repeated hospitalization or excessive amounts of surgery" to effect a satisfactory cosmetic result.

None of the twenty-three patients having definite, consistent anomalous correspondence preoperatively showed a change to normal correspondence following surgery. However, of the four cases of "equivocal" preoperative correspondence, two showed normal correspondence postoperatively while two continued to show ambiguous findings.

4-1

Brown, William T.: *Management of convergence insufficiency and diplopia in a patient with intracranial aneurysm,* Am. J. Ophth., 40:110-111 (July) 1955.

This article reports a case of an adult male who complained of trouble in focusing with his right eye and hazy vision, several months after striking his head during a fall. An intracranial aneurysm was diagnosed, and surgery performed. Postoperative symptoms consisted of vague headaches.

Several years later, the patient was again involved in an accident in which he struck his head. Once more he complained of inability to focus with his right eye and of diplopia which was worse for near and which necessitated occlusion of one eye for close work.

A convergence insufficiency with diplopia at 55 cm. was detected. With the refractive correction (O.D., +1.0△ sph. −1.0△ cyl. ax. 180°; O.S., +87△ sph.−0.87△ cyl. ax. 15°), diplopia occurred at 40 cm.

To eliminate the diplopia, one diopter base-in clipons were prescribed to be worn over the patient's glasses while he was engaged in near work. These made fusion possible up to 25 cm., permitting the comfortable performance of office work.

5-1

Schlossman, Abraham, and Boruchoff, S. Arthur: *Correlation between physiologic and clinical aspects of exotropia,* Am. J. Ophth., 40:53-64, (July) 1955.

The stated purpose of this article is threefold: (1) to determine the importance of exotropia as a form of strabismus; (2) to note outstanding characteristics of the various types of exotropia; (3) to indicate ways in which this information might be useful in the handling of cases of exotropia.

To eliminate some of the confusion in classification, the authors designate all cases of comitant exotropia as either (1) intermittent or (2) constant, subdividing the latter group into those that are (a) alternating and those that are (b) uniocular.

Much of the discussion is concerned with exotropia of the intermittent type, inasmuch as eighty-five per cent of the 324 cases studied showed fusion at some time. The intermittent cases are further divided into seven subgroups depending on the distance at which fusion is present, and they are carefully studied in an endeavor to answer five questions:

1. At what distance can the patient maintain binocular simultaneous fixation?
2. Do most patients fuse intermittently for distance, near, or for both?
3. Is the deviation greater for near or for distance?
4. Are the terms "divergence excess" and "convergence insufficiency" sufficiently well-defined entities to permit categorization of individual cases?
5. How does the NPC help in classifying individual cases?

The study showed that 31.5 per cent of these cases had equal deviations for distance and near, and therefore could not be placed in a definite category. Fifty-three per cent had a greater deviation at near, and sixteen per cent, greater at distance. Remote near points of convergence were found in many cases having a greater deviation at distance, which lead the authors to conclude that the near point cannot be regarded as a guide in categorization. Myopia was found in only 22.8 per cent of the patients. Five per cent of the patients with intermittent exotropia were helped by glasses, and then the benefit was for near only.

The authors emphasize that the presence or absence of fusion in the primary position is the most important single factor in the evaluation of exotropia; upon it, the operative and orthoptic prognoses are based.

Characteristics of patients with constant alternating exotropia include approximately equal visual acuity in both eyes, along with the ability to maintain fixation with either eye although a definite preference may exist for one eye; a moderate refractive error; and a deviation which usually measures more than that in the average case of intermittent exotropia.

In the patients with uniocular constant exotropia, there frequently is amblyopia with inability to maintain fixation with the amblyopic eye and anisometropia. The authors believe that the amblyopia is primary and the deviation secondary in such cases.

The following differences between cases of esotropia and cases of exotropia are cited:

1. Three times as many cases of esotropia occur as of exotropia.
2. More of the cases of exotropia are of the intermittent type, whereas intermittency with esotropia is rare.

3. The incidence of refractive error found in cases of exotropia runs parallel with that found in the general population; hyperopia plays an important part in fifty-six per cent of esotropias, which represents an eighty per cent increase of incidence over that in the general population.

4. Amblyopia is frequent in cases of esotropia, but is found only in cases of uniocular exotropia, the latter group constituting approximately nine per cent of all exotropias.

5-2

Shekter, William B.: *Divergent strabismus with weakness of the inferior rectus muscle,* Am. J. Ophth., 39:359-361 (March) 1955.

Dr. Shekter has found that an underaction of one or both inferior recti is often associated with divergent strabismus. A postoperative analysis of 20 unselected cases of preoperative exotropia with weakness of the inferior rectus is presented. The author believes that cases of exotropia should be measured at a distance greater than six meters in order to uncover any vertical deviation; and he adds that if there is a weakness of the inferior rectus, it should be treated surgically at the same time as is the lateral deviation.

6-1

Schlossman, Abraham: *Alternating esotropia,* Eye, Ear, Nose and Throat Monthly, 34:394-395 (June) 1955.

The author divides esotropia into three large groups: (1) accommodative, (2) alternating, and (3) uniocular. In patients with alternating esotropia the visual acuity of both eyes is relatively equal, and although the patients usually prefer one eye, they can be made to fix with either eye.

A few case histories of patients attending the Department of Motor Anomalies at the New York Eye and Ear Infirmary are cited. The type of operation performed is indicated, the amount of reduction of the angle is given, and the conclusions drawn from the surgery are presented.

It was found that, although a patient with a considerable accommodative element needs less surgery than a patient with a lesser accommodative element, a few separate procedures may nevertheless be necessary. The advisability of conservative surgery done in several stages is explained.

A case is used to show that, despite the fact that the NPC is a variable factor which should not always be used as a criterion for planning surgery, it may be an aid in deciding the type of operative procedure to be followed, particularly in adults.

Another case demonstrates how a very satisfactory surgical result may persist over a period of years even with a change in the refractive error from hyperopia to myopia. However, it is suggested that bifocals, orthoptic training or further surgery might become necessary should the esotropia increase.

Two final cases illustrate how similar types of strabismus may be treated by different types of surgery with equally successful results.

6-2

Schlossman, Abraham and Shier, M.: *Criteria for the management of alternating strabismus,* Am. J. Ophth., 39:351-358 (March) 1955.

The authors reported their impressions of 230 cases of alternating esotropia. These cases were of patients who began to squint in the first year, in the second year, after the second year, and those who were true alternators. Of the group studied, 7.7 per cent had accommodative deviations, 39 per cent had partially accommodative deviations, and 27.2 per cent had nonaccommodative deviations.

The authors suggest that the patients wear their full atropine correction for at least four months before surgery, and that during this time two (or more) atropine refractions should be done to uncover the full amount of hypermetropia, which may have been missed in previous refractions due to incomplete atropinization.

In cases of alternating strabismus the authors feel that orthoptic training plays a minor role both preoperatively and postoperatively.

Included in the article is the choice of surgery according to the amount of deviation present with the dominant eye fixing, amount of deviation with glasses, the near point of convergence, heredity, and the amount of deviation for distance when it is different from that at near. It is suggested that the surgical procedure for the last group should be aimed at the correction of the distant deviation, leaving the residual near deviation for treatment with bifocals and orthoptics.

7-1

Lyle, T. Keith, and Foley, Jill: *Subnormal binocular vision with special reference to peripheral fusion,* Brit. J. Ophth., 39:474-487 (Aug.) 1955.

The authors acknowledge the fact that normal, stable fusion can be obtained in some cases of esotropia, either monocular or alternating, if appropriate treatment is carried out. They feel that the prognosis for attaining such a result is better in squints of later onset and in cases where corrective measures are instituted early.

Noting that equality of vision is considered the first step to binocularity by many authorities, they affirm the value of occlusion as a means of improving acuity in the usually deviating eye. However, they cite two instances in which a rather marked difference in visual acuity existed, but in which fusion and stereopsis could be demonstrated.

The authors point out that, despite adequate surgical and orthoptic treatment, binocular single vision in the usual sense of the term is not achieved in many cases of esotropia. Although some of these patients may appear to use their eyes together, examination on the major amblyoscope often reveals absence of fusion, presence of suppression, and lack of stereopsis.

The authors are particularly concerned with that group of patients having normal retinal correspondence, good visual acuity in each eye, an angle of deviation between zero and ten degrees on the amblyoscope, symmetrical binocular movements, simultaneous perception, and the ability to "join" fusion slides. Burian has suggested that the peripheral fields of the retinas are united by a fusion mechanism in such cases. Orthoptic treatment does not seem indicated for these patients. Cosmetically, a good prognosis can be given, and it is considered unlikely that subsequent divergence will occur. However, the authors emphasize that not all cosmetically satisfactory cases are alike, some being functionally satisfactory as well, while others are only cosmetic corrections and show either "subnormal binocular vision" (normal correspondence with questionable fusion) or "grossly defective binocular vision" (anomalous correspondence, or lack of correspondence).

Peripheral fusion is known to exert a stabilizing effect upon binocular vision, and no doubt aids in maintaining parallelism of the visual axes in many cases despite the presence of central suppression. Its great practical importance lies in the limitation or prevention of consecutive divergence.

The authors describe a screen test for peripheral fusion. The results revealed that peripheral fusion exists not only in patients with binocular single vision, but also in those with convergent strabismus with central suppression. The latter group, however, experienced more frequent peripheral suppression.

A stereoscope test for peripheral fusion is also discussed. Patients having binocular single vision all showed peripheral fusion, although many reported intermittent peripheral suppression. Of those not attaining binocular vision, about one third showed no deviation on the cover test but no fusion on the amblyoscope; peripheral fusion was found in the great majority of these patients on this test. Another third might be classed as having fixation disparities, apparently binocular but not bi-foveal. All in this group showed peripheral fusion, with intermittent peripheral suppression. The other third of the patients not attaining binocular vision had small-angle esotropia of five degrees or less postoperatively, with normal correspondence but no fusion; all of these also claimed peripheral fusion on this test.

From this study, the authors conclude that, although many patients with esotropia who are properly treated with surgery and orthoptics do not subsequently develop binocular single vision, many do improve in respect to both angle of deviation and binocular ability, and are thus seemingly protected from eventual divergence. Such patients are found to possess peripheral fusion.

8-1

Berens, Conrad: *Light clip-on plastic prisms for the temporary correction of heterophoria and heterotropia,* Tr. Am. Acad. Ophth., 59:400-401 (May-June) 1955.

The author describes plastic clip-on prisms which he feels are advantageous if they are to be used for a short period of time. Not only are they of lighter weight, but they are less expensive than glass. They can be repolished by the manufacturer. The use of these prisms is indicated for both horizontal and vertical deviations up to 12△ and sometimes greater; by rotation, combined errors may be corrected.

The amount of prism to be worn is determined by a sceen test in conjunction with

the Maddox rod test, using the prisms at various distances and directions of gaze. The correction is checked while the patient wears the prisms in a trial frame as he is performing the work for which the correction is to be prescribed.

8-2

Diskan, Samuel M.: *A new visual screening test for school children,* Am. J. Ophth., 39:369-374 (March) 1955.

The author presents a new visual screening device called the Atlantic City Eye Test, which was used to screen 799 school children. He claims that it is accurate, quick, and simple to operate. It tests for visual acuity, muscle balance, and manifest hypermetropia at 20 feet. The author feels that the near muscle tests are too inconsistent and would add little to the over-all picture.

Snellen test letters and Snellen E charts were used for testing visual acuity. Anyone under nine years of age failing to read the 20/30 line, or over nine years failing to read the 20/25 plus line, was referred for an eye examination. Plus 1.75 D spheres were used to test manifest hypermetropia, and anyone reading the 20/20 line with this was considered to be in need of further examination.

Muscle balance was tested by the use of red and green glasses, the target consisting of a green rectangle containing a red light. Hyperphoria of more than 1 prism diopter and/or a lateral imbalance of more than 4 prism diopters of exophoria or 6 prism diopters of esophoria would place the red light outside of the rectangle, and this constituted a failure. All children failing the first test were retested; 13 per cent passed the second time.

The author feels that, unlike many school eye tests which have a high rate of false referral, the new screening device is superior in detecting those children with real need for an eye examination. Testing time per person averaged 70 seconds as compared with the Massachusetts test which requires 2.4 minutes.

8-3

Fernandez, R.H.P.; Edmonds, O.P., and Hunt, T. A.: *Binocular diaphragm,* Brit. J. Ophth., 39:343-348 (June) 1955.

The authors describe a test called the "binocular diaphragm" which is used to determine distant visual acuity under binocular conditions. It requires a diaphragm with a 4.5 cm. aperture situated midway between the eyes of the patient and the Snellen-test type card. The diaphragm is approximately the same size as the vision card. In addition to the letters, the chart contains five black lines and two red reflectors.

By means of this device, uniocularity can be detected, as can a hyperphoria of .75 diopters or more, or an esophoria of 3 to 35 diopters. The test also differentiates binocular visual acuity from that of each eye tested separately. Furthermore, it elicits accommodation and thus demonstrates cases of excessive accommodation due to hyperphoria. The test does not reveal small degrees of exophoria, but it does detect divergence excess.

Trial tests utilizing the binocular diaphragm are reviewed, and the conclusions presented.

8-4

Fink, Walter H.: *Instrument designed to test diplopia fields,* Am. J. Ophth., 40:424-425 (Sept.) 1955.

The author describes an instrument consisting of a small flashlight on which is mounted an elongated head at right angles to the flashlight. A slit in the head produces a narrow line of light when the flashlight is turned on. This instrument is designed to simplify the study of diplopia fields, and is particularly valuable in the analysis of torsional defects. The technique of the test is described.

8-5

Krimsky, Emanuel: *A new hand stereoscope,* Tr. Am. Acad. Ophth., 59:539-540 (July-Aug.) 1955.

A new hand stereoscope devised by the author for home use is described. The differences between it and other types of hand stereoscopes are enumerated:

1. Larger (2¼ inches) transparencies may be used, as well as the conventional smaller (35 mm.) ones.
2. The uncomplicated structure presents no obstacle to a view of the patient's eyes; the examiner can easily observe any regression to monocularity.
3. The rimless inner edges of the large lenses offer no blockage of the patient's view of the picture.

8-6

Krimsky, Emanuel: *A new near-point rule,* Tr. Am. Acad. Ophth., 59:540-541 (July-Aug.) 1955.

A new near-point rule contrived by the author is described. Its advantages over the Prince rule consist in (1) the use of a bifurcated rod which rests against both cheeks, affording the patient a more symmetrical view; (2) the incorporation of a light in place of a white-headed pin, providing more stimulus to the patient and enabling the examiner to make a more accurate objective reading; (3) the provision of two reading cards for accommodation.

8-7

Olmsted, K. Elizabeth Pierce: *Lens to encourage macular perception,* Am. J. Ophth., 40:419-423 (Sept.) 1955.

A lens incorporating a diffraction grating to form a diffused retinal image is described. It was devised to encourage physiologic rivalry and binocular perception in cases of squint. This lens is used before the dominant eye, usually after visual acuity of the amblyopic eye has been improved to 20/30. The object of the lens is to produce reduction in the resolving power of the dominant eye to one or more lines below that of the other eye. Several case reports are given. The author is encouraged by her results from the use of the lens.

8-8

Schwarting, Bland H.: *Testing infants' vision,* Am. J. Ophth., 38:714-715 (Nov.) 1954.

The author describes a homemade device for estimating the visual acuity of young children and infants. The usefulness of the gadget depends upon the early establishment of the "following reflex" and upon the natural curiosity of the child.

Various sizes of wire, calibrated to the Snellen chart, are attached to the swinging arm of a metronome which appears in front of an illuminated box. The device is placed at a distance of one meter from the patient in a dark room. If it is noted positively by the examiner that the infant fixes upon the steady movement of the object in the illuminated field, the visual acuity can be estimated according to the caliber of the wire.

The report contains a description of the testing conditions for the device, the mechanics of the apparatus with pictures, and an interpretation of its value as an objective test.

9-1

Schlossman, Abraham: *Excerpts from Javal,* Eye, Ear, Nose and Throat Monthly, 34:456-457 (July) 1955.

Many of our present-day concepts of treatment are developments of ideas expressed by great men of the past. Emile Javal was one of the foremost contributors by means of his textbook, "Manuel du Strabisme".

Donders pointed out the frequency of esotropia associated with hypermetropia. The use of a combination of convex lenses for distance vision and an occluder for near vision is very effective. Bifocals are also of use, although the strength of the segment should be gradually reduced. If the total hypermetropia is not too great, the patient should attempt to learn to maintain single binocular vision without wearing his correction.

A patient with myopia who has an esotropia should have the benefit of concave lenses.

Atropine is valuable as a means of occlusion. Children can tolerate a daily dosage of 1 mg., or two drops of a 1 per cent solution.

Eserine and pilocarpine cause an involuntary increase in accommodation, enabling the patient to see clearly without any additional convergence.

10-1

Lloyd, J.P.F.: *Left paralytic convergent squint,* Brit. J. Ophth., 39:572 (Sept.) 1955.

A case of a 72-year-old woman with a complete paralysis of the left external rectus is presented. The squint had been present for twenty years. The visual acuity in the right eye was 6/5 corrected, and in the left eye, finger counting.

A "Gifford" reconstruction of the external rectus and a 6 mm. recession of the internal rectus were performed. Eight weeks postoperatively, the left eye had very nearly full movements, with the exception of a little weakness of the left internal rectus. The visual acuity in the left eye returned to 6/5. The patient became almost completely free from diplopia.

10-2

Schlossman, Abraham: *Ocular palsies caused by systemic diseases,* Eye, Ear, Nose and Throat Monthly, 34:599 (Sept.) 1955.

The author lists some general diseases which may be associated with ocular palsies. His discussion is limited to four of these diseases: diabetes, thyrotoxic and thyrotropic exophthalmos, multiple sclerosis and myasthenia gravis.

11-1

Breinin, Goodwin M., and Moldaver, Joseph: *Electromyography of the human extraocular muscles,* A.M.A. Arch. Ophth., 54:200-210 (Aug.) 1955.

Doctors Breinin and Moldaver believe that electromyography will prove a useful aid in studying innervational factors affecting the extraocular muscles. They are preparing a series of papers concerned with such studies in the following fields: kinesiology of the extraocular muscles, paretic strabismus, nystagmus, supranuclear mechanisms, comitant strabismus, myopathies and neuropathies. This preliminary report deals with the kinesiology of the extraocular muscles in normal subjects and in one subject with intermittent exotropia.

Electromyographic data presented show that the extraocular muscles are actively innervated at all times, there being no absolute position of rest as in skeletal muscle. This activity is quite marked when the eyes are in the primary position. As a muscle is moved into its field of action, its action potential increases while that of its antagonist decreases accordingly. This holds true in both versions and vergences. Thus is Sherrington's law of reciprocal innervation exemplified.

A case of intermittent exotropia is described in which active innervation of the lateral recti was demonstrated. This indicates that divergence is probably an independent function with a yet-to-be-discovered center, rather than merely the inhibition of convergence as has been believed.

11-2

Cowan, Alfred: *The role of the pupil in ametropia,* Am. J. Ophth., 40:481-485 (Oct.) 1955.

The author gives the characteristics of what he believes to be the ideal pupillary entrance insofar as both physical and physiological properties are concerned. He points out the close relationship in size and shape between the pupillary entrance and the rays which form the retinal image, especially in ametropia.

Among other facets of the subject, the author explains how pupillary constriction increases acuity by reducing the spread of the diffusion image, aiding either the unaccommodated emmetropic eye or the ametropic eye to obtain clearer vision.

In emmetropia, proper pupillary size is designated as that which permits the sharpest possible image through the response of the iris to light, accommodation and convergence. If a normal or adequate response is not possible, ocular fatigue and symptoms may develop.

11-3

Swan, Kenneth C.: *The blindspot mechanism in strabismus,* Am. J. Ophth., 38:765-776 (Dec.) 1954.

The author presents a résumé of the early literature pertaining to the blindspot mechanism, as well as revisions and additions to his own earlier writings on this subject.

A description of the normal physiology of binocular vision is given. The utilization of the blindspot mechanism in strabismus is explained. Incidence, diagnosis, prognosis and treatment of the blindspot syndrome are discussed. Several diagrams and illustrations are included.

12-1

Eames, Thomas H.: *The influence of hypermetropia and myopia on reading achievement,* Am. J. Ophth., 39:375-377 (March) 1955.

The author tested 171 school children in the third and fourth grades using the Gates silent-reading test. Fifty of these children were used as a control group. Of the others, 57 who had passing grades and 64 who had failed in reading at school received eye examinations.

It was shown that in the nonfailing group emmetropes and hypermetropes had the same reading ability, while the myopes were slightly more advanced. In the failing group the hypermetropes had the most reading difficulty, the myopes less, and the emmetropes the least.

The author concludes that in pupils doing passing work, refractive errors make little differ-

ence; but in pupils who are failing, refractive errors will contribute to their retardation. He therefore advocates complete eye examination for all retarded readers.

12-2

Folk, Eugene R., and Whelchel, Merritt C.: *The effect of the correction of refractive errors on nonparalytic esotropia,* Am. J. Ophth., 40:232-236 (Aug.) 1955.

The authors present the results of a survey investigating the effect of correction of the refractive error on the angle of squint. Three hundred fifty-one cases of essentially comitant esotropia were reviewed. These patients were refracted, fitted with glasses, and then observed. Occlusion, if indicated, was the only other form of treatment prescribed.

Several factors were considered in this study. The age at onset of squint was checked and found to vary, but could be placed at four years or earlier in more than eighty per cent of the cases. As might be expected, those with onset at a later age—between two and a half and five and a half years of age—were given a more favorable prognosis than those with an earlier onset. Similarly, those with a shorter duration of squint before refraction, and those with an intermittent deviation, obtained a relatively high percentage of good results.

Atropine cycloplegia was done on all children included in the survey. It was noted that if the eyes straightened under cycloplegia, the prognosis of cure through wearing the proper prescription was favorable. The greater the refractive error, the more pronounced was the benefit derived from the wearing of glasses. Anisometropia did not seem to play a significant part in the cases observed. Hyperopia and astigmatism were corrected fully, although undercorrections were revealed in subsequent reexaminations of many of the cases. Myopia was found in only twelve patients.

Maximum benefit from the glasses was attained after a two-month trial period in ninety-two per cent of the cases. The remaining eight per cent required a longer trial period, determined by the rate of visual improvement in amblyopes and by the ability to adjust to full correction in high hyperopes. In twenty-eight per cent of the patients in the survey, the eyes were straightened with proper optical correction; an additional nine per cent showed a reduction of fifty per cent or more in their angle of deviation; and the remainder showed little or no change. Deviations less than twenty degrees were found to respond best to glasses. Bifocals were considered helpful in the majority of cases in which they were prescribed.

Ten per cent of the patients who had been successfully treated with glasses alone later developed an esotropia. Of these, approximately one half had shown a marked esophoria with their glasses; another one third had been undercorrected, but attained fusion when given full correction; and two or three were believed to have been lax in the use of partial occlusion.

Twenty per cent of the seventy patients whose eyes were straightened with glasses were later able to maintain comfortable binocular vision without glasses.

13-1

Ogle, Kenneth N.: *Stereopsis and vertical disparity,* A.M.A. Arch. Ophth., 53:495-504 (April) 1955.

The author, using a point source of light as a test object and a light source seen simultaneously by the two eyes as a fixation point, experimentally showed that stereopsis is appreciated despite comparatively large vertical disparities, up to approximately twenty-five minutes of arc. Furthermore, he demonstrated that the grade or quality of stereopsis remains quite constant, regardless of the degree of disparity, until the end point is reached. This holds true even when the test object is placed within half a degree of the fixation point, and even when vertical diplopia is appreciated on the test object.

The amount of vertical disparity that does not affect stereopsis decreases as the test light is moved farther from the fixation point toward the peripheral field of vision, and as the horizontal disparity of the images is increased. However, in cases where an additional "reference object" is placed immediately before or behind the fixation point and where stereopsis is judged in relation to the "reference object," a horizontal disparity of images does not limit to the same extent the amount of vertical disparity which may be tolerated.

14-1

Costenbader, F. D., and Bair, D. R.: *Strabismus surgery—monocular or binocular?,* A.M.A. Arch. Ophth., 52:655-663 (Nov.) 1954.

In their review of 665 cases of strabismus in which surgery had been performed, the authors' stated purposes were (1) to determine

whether monocular or binocular surgery resulted in a greater incidence of postoperative comitance; and (2) to determine the importance of comitance in attaining the goal of treatment, binocular single vision.

Previously discussed causes of failure—persistent amblyopia and anomalous retinal correspondence, the presence of a vertical element along with a horizontal squint, and inability or neglect in separating the accommodative element from the nonaccommodative element—were reviewed. The possibility of incomitance as an additional cause of failure was suggested.

Of the 665 cases of strabismus reviewed, 535 were nonaccommodative or partially accommodative esotropias; 131 were exotropias. Only patients with definite preoperative comitance, i.e., a difference of ten diopters or less in the angle of deviation as measured in the two lateral fields, were considered in the analysis.

Combinations of surgical procedures employed in this series of cases included the following:

1. Symmetrical simultaneous surgery, in which surgery was done on corresponding muscles in the two eyes at one operative session

2. Symmetrical consecutive surgery, in which surgery was done on corresponding muscles of the two eyes at different times

3. Non-symmetrical surgery, in which surgery was done on one eye only

In those patients who had adequate immediate postoperative measurements, the following results were noted: Following the first type of surgical procedure, eighty-seven per cent of the esotropias were immediately comitant and ninety-six per cent were comitant eighteen months following surgery; ninety-eight per cent of the exotropias were immediately comitant. After the second type of treatment, forty-seven per cent of the patients were incomitant after the first operation, but only eighteen per cent remained so after subsequent surgery. As a result of the third type of treatment, monocular recession resulted in incomitance in forty-two per cent of the cases whereas recession and resection resulted in lack of comitance in sixty-one per cent of the cases; considering both subgroups together, sixty-five per cent were immediately incomitant postoperatively, whereas fifty-two per cent remained incomitant two and a half years postoperatively.

The authors found that those patients who were comitant postoperatively showed a higher percentage of successful results (straight eyes and normal retinal correspondence) than those who were incomitant, the latter group tending to show residual deviations and anomalous retinal correspondence. They conclude that if their survey does not establish an indisputable relationship of comitance to straight eyes and normal retinal correspondence, it at least points up an ". . . association . . . [which] seems significant."

14-2

Foggitt, K. Dean: *Recession-lengthening of medial recti for convergent squint: a preliminary report,* Brit. J. Ophth., 39:488-494 (Aug.) 1955.

Abnormal medial recti showing some tendency toward fibrosis are said to be a not uncommon finding at the time of surgery, and are usually associated with congenital esotropias. Ordinarily such cases show a limitation of abduction, seemingly indicating a paretic lateral rectus, but forced rotation tests point to abnormalities of the medial rectus instead.

Neither a bilateral recession of the medial recti nor a resection-advancement of the lateral recti seems a satisfactory surgical procedure in such cases. Recession-lengthening of the medial recti appears to yield better results, effecting a weakening of the overly-powerful medial recti and affording an opportunity for the lateral recti to act normally.

Both clinical and operative indications for the recession-lengthening procedure are given. Clinical indications include (1) esotropia of congenital origin with limited abduction of one or both eyes; (2) paretic lateral rectus accompanied by a contracture of the medial rectus; (3) a highly variable angle of deviation incompletely corrected by glasses, the maximum angle being at least twenty degrees larger than the small minimum angle; and (4) powerful but spasmodic convergence. Operative indications include (1) straight eyes under anesthesia; (2) abnormally thick medial recti; and (3) fibrotic tissue of the medial recti.

Contraindications are listed as (1) an angle of squint less than twenty degrees; (2) a comitant and constant or stable angle of deviation; (3) a difference of less than twenty degrees between the minimum and maximum angle of squint; (4) full rotations.

The technique of the operation is presented.

The author warns of the dangers of the recession-lengthening procedure, notably hemorrhage and proptosis. Overcorrection is purportedly rare provided attention is paid to the

indications and contraindications specified, and provided resection of the lateral rectus is not performed during the same operation. Occasionally, limitation of adduction may follow postoperatively. Supposedly, recession-lengthening of *both* medial recti is necessary to effect the desired result.

The author reports that the results of the operation can be assessed two or three weeks postoperatively. He points out that the chief advantages of this operative technique are the maintenance of normal convergence ability and the reduction of contractile tissue in the myotomized muscle.

14-3

Mulberger, Robert D., and McDonald, P. Robb: *Surgical management of nonparalytic exotropia,* A.M.A. Arch. Ophth., 52:664-668 (Nov.) 1954.

The diversity of procedures employed by various surgeons in the correction of exotropia seemed potentially confusing, as well as unnecessary to the authors, in the attainment of either of the two goals of surgical intervention: binocular single vision and cosmetic correction. They felt that the first goal could best be attained through early surgery; the second through employment of proper surgical procedures.

Nonparalytic exotropias were divided by the authors into four classifications, and a recommended surgical procedure given for each class:

1. Intermittent exotropia: bilateral recession of the external recti to the equator; in cases in which the near point of convergence is poor, bilateral resection of the internal recti.

2. Alternating exotropia: for small degrees, bilateral recession of the external recti; for larger degrees, bilateral resection of the internal recti; in some cases, both procedures, probably in two separate stages.

3. Constant exotropia: resection of the internal rectus and recession of the external rectus of the divergent (and usually amblyopic) eye.

4. Postoperative exotropia (overcorrected esotropia) — in general, the muscles originally operated upon should be reoperated on first, keeping in mind that more surgery is necessary to correct an overcorrection of esotropia than was necessary to produce the overcorrection originally.

For this study, the authors reviewed the records of 147 patients with exotropia on which fifteen types of surgical procedures had been performed by a number of doctors in two local hospitals. Seventy-six per cent of the patients were improved postoperatively, but only forty-seven per cent had straight eyes. In contrast, review of a smaller series of thirty-eight private patients with exotropia operated on by the authors in accordance with the principles outlined in the article revealed that ninety-seven per cent had been improved, and seventy-eight per cent had been given straight eyes.

14-4

O'Connor, R.: *The cinch operation,* Brit. J. Ophth., 39:495-502 (Aug.) 1955.

Neither suturing nor cutting of the extraocular muscle tendon is necessary in the course of the cinch operation. Limited postoperative occlusion and elimination of postoperative confinement during recovery are two of the many advantages which the author attributes to this form of surgery.

Indications for this form of muscle surgery are given by the author: "(1) As a tendon shortening whenever such an effect is indicated. (2) As a non-slipping anchorage whenever a tendon suture is needed . . . and as a guard in complete tenotomy."

The operative technique is described in careful detail, step by step.

The author notes that many references in ophthalmological literature allege extreme reactions following the cinch operation. He feels that these reactions may be avoided through recognition of the principal causes, which include "rough" surgery; allergy of the patient to medications, and even to the sutures, employed; irritation of the eyes from irrigation; and infection developing around the site of the sutures.

In conclusion, the opinions of several surgeons whose experience with the cinch operation led them to regard it as a superior surgical technique are reported.

14-5

Schlossman, Abraham: *Surgery of the inferior oblique,* Eye, Ear, Nose and Throat Monthly, 34:328-329 (May) 1955.

The author notes that overaction of the inferior oblique is often found in cases of lateral

strabismus. When the vertical component is greater than seven prism diopters in primary position, or of a smaller degree in cases in which it is possible to obtain a functional correction, he believes that surgery is indicated. When the vertical deviation is greater than the horizontal, surgery on the inferior oblique may be the primary procedure.

The following methods, described by the author in detail, may be used for correction of overaction of the inferior oblique: (1) tenotomy at the origin, which is popular because of its simplicity, but which gives unpredictable results; (2) myotomy or myectomy near the insertion, which the author feels is of special value when the overaction of the inferior oblique is so great that the recession alone will not yield a satisfactory result; and (3) recession of the inferior oblique, which is the most popular form of surgery on this muscle, and in which the surgery can be controlled better than in the other procedures.

Underaction of the inferior oblique is a much rarer deviation. Three procedures for correction were listed and described by the author: (1) tucking; (2) advancement of the insertion; (3) resection of the inferior oblique, which can also be combined with an advancement.

15-1

Quereau, J. V. D.: *Rolling of the eye around its visual axis during normal ocular movements,* A.M.A. Arch. Ophth., 53:807-810 (June) 1955.

This is a report of a study of the rolling of the eyes around the visual axis during normal rotations. In this study, Quereau has made use of the physiological blind spot by plotting its position in different directions of gaze on a spherical coordinate system.

It was found that the apparent rolling of the eye in the oblique positions was actually torsion (false torsion) due to the observer having used horizontal and vertical lines rather than the meridian of longitude which the visual line followed as his point of reference. In extreme degrees of oblique rotation there was slight rolling of the eye, outward in the superior temporal quadrant and inward in the inferior temporal quadrant. This was considered normal. When the eyes made movements other than toward or away from the primary position, the position of the blind spot showed that the eye rolls around its visual axis so that a meridian of the retina assumes the same angle with the meridian of longitude that it is crossing as though the eye were in the primary position.

The author's method of plotting the physiological blind spot is useful in the detection of pathological rolling. A case of paresis of a left inferior oblique is presented as an illustration.

16-1

Breinin, Goodwin M.: *The nature of vergence revealed by electromyography,* A.M.A. Arch. Ophth., 54:407-409 (Sept.) 1955.

In this article the author presents further information, derived from electromyographic studies, on the nature of the vergence movements. He uses a case of intermittent exotropia to illustrate Hering's explanation of asymmetrical convergence. Thus, almost simultaneous impulses to a vergence and version movement may result in no apparent increase in innervation to the preferred eye, while the nonpreferred eye may show a doubly strong innervation.

The author asserts that the electromyographic tests have demonstrated that the sensory apparatus of the eye controls the motor apparatus and have corroborated the laws of Hering and of Sherrington.

17-1

Cushman, Beulah: *Hyperphoria and some of its problems,* Am. J. Ophth., 40:332-343 (Sept.) 1955.

The author follows the thinking of Dr. James W. White in her approach to anomalies of the extraocular muscles. She emphasizes the importance of determining the etiology, and of measuring vertical deviations in the cardinal fields before an attempt is made to establish a diagnosis. In connection with vertical squint, she points out the tendency toward comitance with the passage of time.

In her consideration of the etiology of strabismus, Dr. Cushman mentions the part played by refractive errors and congenital anomalies. She believes, however, that strabismus may usually be regarded as a developmental phenomenon; i.e., that if normal binocular development is interfered with, strabismus may and often does result. She quotes Keiner, who thought squint could be described as ". . . re-

tardation in the normal development of the tracts and connections of certain parts of the central nervous system."

With regard to congenital pareses, the author reports that embryologic studies often reveal abnormalities of the ocular muscles in their rudimentary stages. Postnatally, pareses of the elevators are detected much earlier than pareses of the depressors, because the child, being short, necessarily looks up very frequently.

The term paresis is defined, and the two commonly associated overactions are indicated: that of the yoke muscle in the opposite eye, and that of the antagonist in the same eye. The role played by fixation preference in determining the field of greatest vertical deviation is explained. When the preferred eye is the paretic eye, the vertical deviation can be expected to increase maximally in the field of the yoke muscle; when the preferred eye is the nonparetic eye, the vertical deviation will be greatest in the field of the antagonist.

The superior rectus is singled out as the vertical muscle most often paretic. Paresis of the inferior rectus ranks next in frequency, and is often found in association with a divergent deviation. Early surgery is recommended in the latter case, to avoid development of a remote near point of convergence and to reduce the amount of surgery necessary.

The author considers phorias and tropias to be basically similar conditions, differing mainly in degree. Therefore, the treatment should be the same for both conditions. Surgery is strongly urged before the phoria becomes a tropia.

In her experience, Dr. Cushman has found that several months to a year may elapse before binocular vision develops following successful surgery. She believes that postoperative orthoptic training is unnecessary in cases in which adequate surgery has been performed following an accurate diagnosis which, in turn, has followed a careful study of etiologic factors.

17-2

Fink, Walter H., *The role of developmental anomalies in vertical muscle defects,* Am. J. Ophth., 40:529-555 (Oct.) 1955.

Opinion varies as to the primary cause of vertical deviations. The two causes most frequently singled out are developmental anomalies and paretic elements. The author presents evidence regarding the role of the first factor, since he has found the incidence of vertical anomalies to be considerably higher than is generally expected.

The importance of determining the cause of a vertical deviation is explained, particularly with regard to judging the amount of surgery to be performed. The author admits the difficulties of diagnosing anomalies of vertical development preoperatively, and even at the time of surgery, but lists several factors which are suggestive of their presence: (1) onset at birth; (2) no history of disease or injury; (3) no sign of central nervous system involvement; (4) a defect mechanical in nature; (5) limited movement on forced duction test; and (6) "fixed muscle" duction test as used by Johnson.

Forms of developmental abnormalities mentioned include total absence of a vertical muscle, inelasticity of the extraocular muscle (either because of a congenital structural abnormality or from prolonged contraction or spasm), abnormal muscle insertions, fusion of fascial sheaths of two or more muscles, and fibrosis of a muscle.

In conclusion, the author states that knowledge of vertical anomalies is still limited because of (1) relatively infrequent surgery, (2) a limited area of exposure at the time of vertical surgery, and (3) a lack of knowledge of the atonomy of the area. He believes that vertical anomalies do occur, more frequently in some areas than in others, and probably more frequently than horizontal anomalies, in view of the more complex nature of vertical anatomy. He stresses the importance of correct diagnosis when possible, inasmuch as a relatively simple surgical procedure may then effect the goal of binocular vision without trauma to the extraocular muscle.

17-3

Lebensohn, James E.: *Nature of innervational hyperphoria,* Am. J. Ophth., 39:854-858 (June) 1955.

Because the ocular muscles have such strength, hyperphoria is thought to be of an innervational origin rather than attributable to muscular weakness. The author states that the incidence of hyperphoria is relatively high in connection with anisometropia, aniseikonia, and excessive esophoria or exophoria.

Measurement of a vertical phoria at both distance and near settings, and with both the right and left eyes fixating in turn, is advised as a routine procedure. In a series of 100 cases, 66 patients showed more heterophoria when

the Maddox rod was held in front of the nondominant eye. It is recommended that near measurements be done in the reading position, and that the Maddox rod and prism be held in front of the same eye to ensure steady fixation with one eye.

Characteristics of inhibitive hyperphoria are given as (1) elevation or depression within moderate limits; (2) a small disparity, if any, between primary and secondary deviations; (3) a small variation upon dextroversion and levoversion; (4) control of symptoms by proper prismatic correction.

The following clinical suggestions are among those made by the author:

1. The imbalance at near is more important. With small amounts, there will be discomfort because of lack of suppression. Often the phoria at near only is corrected.
2. If the patient always fixes with the involved eye, the larger prism should be put over the opposite eye to correct the secondary deviation.
3. A hyperphoria which varies when the eyes move to right and left is not helped by prisms.
4. Adults with anisometropia should be tested for anisophoria, inasmuch as the two conditions are often found together.

17-4

Urrets-Zavalia, Alberto: *Significance of congenital cyclo-vertical motor defects of the eyes,* Brit. J. Ophth., 39:11-20 (Jan.) 1955.

The author has been studying the relationship between vertical and horizontal deviations. It is his belief that vertical factors are the underlying cause, in more cases than is realized, of esotropia and exotropia thought to be comitant. In line with this thought he says that "the position of the eyes in direct elevation and depression is extremely important, since these may give rise to a relative divergence or convergence of the visual axes of a prominent diagnostic value." While there is no final answer, the author suggests that this is due to a "lack of balance which appears between the abducting and adducting components of the elevators, and between those of the depressors as well, as a result of faulty contraction of one of these muscles . . . ."

Urrets-Zavalia feels that two basic groups of vertical imbalance may be established according to "(1) the vertical changes suffered by the reciprocal position of the eyes as they rotate upon a vertical axis, (2) the variations to which the horizontal relationship of both visual axes are subjected as they move around a transversal line."

According to previous articles by Dr. Urrets-Zavalia, this type of deviation appears to be congenital and developmental. He states that Bielschowsky's type of alternating hyperphoria is not the same type as this, although confusion over the diagnosis may occur.

The author has also previously described the condition that exists when the vertical deviation is large enough to disrupt binocular fusion. There is a dissociation of the eyes and a release of cortical control over convergence and accommodation. In some instances the binocular control is strong enough to remain, but this is done in the primary position of the eyes only, with very little, if any, amplitude. Cyclovertical imbalance and horizontal deviations are also noted in certain fields of gaze but these are incomitant.

A classification of comitant strabismus is given according to the factors influencing dissociation. The author has noted that in cases of congenital cyclovertical deviation there is often a slight facial malformation.

In cases of deviations without divergence and convergence when the eyes are elevated or depressed and without facial manifestations, the author believes that the vertical component is secondary to the horizontal.

17-5

Villaseca, Alfredo: *Surgical classification of squints with a vertical deviation,* Brit. J. Ophth., 39:129-150 (Mar.) 1955.

Villaseca presents a review of sixteen cases of squint with a vertical deviation. These are classified as (1) primary vertical strabismus with or without horizontal deviation; (2) secondary vertical deviations; or (3) mixed cases.

The first group is subdivided into cases with a paresis of either the elevator or depressor muscle of one eye, paresis of both elevators or depressors of one eye, bilateral paresis of twin muscles, or mixed deviations. Many of the above deviations are accompanied by a horizontal deviation as well. Added to these are the cases of double hyperphorias, some with no horizontal involvement. In each case the preoperative and postoperative measurements, includ-

ing synoptophore measurements and degree of fusion, are presented. The type of surgery used in each case is discussed.

The second group, discussed under the subheading "Urist Syndromes", deals mainly with permanent convergent and divergent deviations that have developed secondary vertical deviations. The author gives methods of classification, and discusses the use of occlusion and surgical treatment.

In his "methods of classification", Dr. Villaseca stresses the period of dissociation that is necessary. This is done by permanent occlusion, monocularly on the nondominant eye and then alternately. When the deviation is more marked in the vertical than in the horizontal, it is classed as a primary vertical deviation.

Dr. Villaseca discusses the surgical procedures recommended for the two types of cases. In secondary deviations, he suggests that the horizontal be dealt with first. The vertical should then clear in a period up to two months. Concerning the "primary vertical deviations" with a horizontal deviation as well, he feels that both deviations should be corrected surgically at one time.

The last group discussed is the "mixed cases." These are the cases in which the patient has "two different types of primary vertical squint" or a combination of primary and secondary vertical strabismus. A case of unequal paresis of both superior recti, combined with Urist's syndrome group 1 is presented, and the surgical procedure which was utilized is described.

Dr. Villaseca again stressed "that a period of dissociation by occlusion is always necessary before a final classification is made."

18-1

Eames, Thomas H.: *Correlation between birth weight and visual acuity,* Am. J. Ophth., 38:850-851 (Dec.) 1954.

This article presents a statistical analysis of a study of the effect of birth weight on visual acuity.

The relationship between birth weights of over five pounds and visual acuity was minimal. A somewhat more marked relationship between birth weights of under five pounds and visual acuity was found.

The author wishes to stress that the "tendencies shown are of more importance than the actual numerical values" printed in the correlation table.

18-2

Foxell, C.A.P. and Stevens, W.R.: *Measurements of visual acuity,* Brit. J. Ophth., 39:513-533 (Sept.) 1955.

In the experiments conducted prior to the writing of this article, several factors thought to be important for their possible effect on visual acuity were carefully checked. These included the type of test object used, the contrast of the test object with the background, the luminance of the visual field (both the "central field" and the "surround"), the color of the backgrounds, the effect of movement of the test object, the criteria for detecting detail, the effect of exposure time of the test object, and the alertness and reliability of the observers tested.

A black Landolt broken circle on a white background was used as a test object. Experiments were also carried out with colored test objects, but the changes in the apparent brightness of the colored test objects with changes in size made observation difficult.

Individual testing sessions were usually limited to one-half hour, to avoid fatigue. The observers were allowed as much time as they wished for each response, usually taking from one to five seconds. All observers employed were especially selected for their consistency and accuracy in reporting.

The factor most affecting visual acuity was found to be ". . . the luminance of the small immediate background to the visual task," an increase in the background luminance effecting a relatively large improvement in the visual acuity. A large bright surround was judged unnecessary to good visual acuity.

18-3

Spaeth, Edmund B.; Fralick, F. Bruce, and Hughes, William F. Jr.: *Estimation of loss of visual efficiency,* A.M.A. Arch. Ophth., 54:462-468 (Sept.) 1955.

The authors' definition of visual efficiency embraces many factors, the major ones being central visual acuity, peripheral visual fields, motility, and binocular vision.

In considering central visual acuity, testing conditions and equipment are described, and the form for recording vision is explained. The authors emphasize the difference between the fractional notation and the mathematical percentage of visual acuity. Comparisons are made

between visual acuities of the same Snellen notations for distance and near, and the influence of factors other than acuity on visual efficiency, especially for near vision, is considered. Aphakia as a form of visual disability, elaborating on the relative handicaps of monocular and binocular aphakia, is discussed.

For determining visual fields, testing conditions and equipment are specified, the technique is briefly outlined, and the advisability of repeated tests is indicated. Norms are given for each of the field meridians.

On the subject of ocular motility, the importance of both the negative factor of absence of diplopia and the positive factor of binocular vision is pointed out. The authors believe that diplopia is not a form of visual disability ". . . unless it is present within 30° of the center of fixation." Absence of binocular vision without diplopia is thought to ". . . not represent more than a 50 per cent loss of ocular motility efficiency of one eye in the average case", unless good depth perception is a requisite for the patient's work.

The authors present a formula for calculating the mathematical percentage of visual efficiency, incorporating all the factors mentioned. After their explanation, they indicate the minimum standards: "Should the total binocular visual efficiency of the patient be less than 10 per cent, for all practical purposes the patient can be considered blind."

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Dept. of Ophthalmology
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Department of Ophthalmology
Washington University School of Medicine
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Mrs. Elsie H. Laughlin
Dept. of Ophthalmology
Iowa University Hospitals
Iowa City, Iowa
Sponsor: Alson E. Braley, M.D.

Miss Marion P. Lister
Orthoptic Clinic
717 Medical Dental Bldg.
Vancouver 1, B. C., Canada
Sponsor: John A. McLean, M.D.

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Detroit 26, Mich.
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Orthoptic Clinic
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Sponsor: John A. McLean, M.D.

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Orthoptic Clinic
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259 Alexander St.
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Ophthalmic Laboratory
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717 Medical Dental Bldg.
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311 Doctors Bldg.
478 Peachtree St., N.E.
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Sponsor: Alton V. Hallum, M.D.

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Orthoptic Clinic
University of Colorado Medical Center
4200 E. Ninth Ave.
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Oakland Orthoptic Laboratory
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Indianapolis, Ind.
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8 West St.
Danbury, Conn.
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Miss Alice Pop
Orthoptic Clinic
Health Centre for Children
Vancouver General Hospital
Vancouver, B. C., Canada
Sponsor: John A. McLean, M.D.

Mrs. Dolores Jalbert Pumphrey
100 N. Main St.
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Miss Jane Romanio
Orthoptic Clinic
New York Eye and Ear Infirmary
218 2nd Ave.
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Orthoptic Clinic
Ohio State University Hospital
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Orthoptic Dept.
EENT Hospital
145 Elk Place
New Orleans, La.
Sponsor: James H. Allen, M.D.

Mrs. Donna Orlando Scharlach
Buffalo Orthoptic Center
52 Maple St.
Buffalo 4, N. Y.
Sponsor: Howard H. Higgs, M.D.

Miss Martha M. Schuster
Kansas City Orthoptic Clinic
248 Plaza Theatre Bldg.
4711 Central
Kansas City, Mo.
Sponsor: John McLeod, M.D.

Mrs. Ruth MacNab Schwarz
13210 Shaker Square
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Miss Edith E. Scott
402 Cobb Bldg.
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Miss Mary Glen Sharpe
Orthoptic Clinic
Hahnemann Hospital
Philadelphia 2, Pa.
Sponsor: H. S. Weaver, Jr., M.D.

Miss Susanne Shears
736 Granville St.
306 Vancouver Block
Vancouver, B. C., Canada
Sponsor: A. R. Anthony, M.D.

Miss Diane E. Smith
100-103 Medical Dental Bldg.
12th Ave. and 2nd St., West
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Miss Marjorie Snell
Orthoptic Clinic
Children's Hospital
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Sponsor: I. H. Beckman, M.D.

Miss Donna Speicher
Kansas City Orthoptic Clinic
248 Plaza Theatre Bldg.
Kansas City, Mo.
Conrad, Iowa
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Mrs. Rosa DeCarlo Spero
35-36 193rd St.
Flushing, N. Y.
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Miss Mary Virginia Stallworth
Orthoptic Clinic
University of Alabama Medical Center
Birmingham, Ala.
Sponsor: Thomas O. Paul, M.D.

Miss Elisabeth B. Stanley
Orthoptic Clinic
New York Eye and Ear Infirmary
218 Second Ave.
New York 3, N. Y.
Sponsor: Truman L. Boyes, M.D.

Miss Elizabeth K. Stark
30 E. 40th St.
New York 16, N. Y.
Sponsor: Harry Eggers, M.D.

Miss Arlene E. Stearns
1652 David Whitney Bldg.
Detroit 26, Mich.
Sponsor: A. D. Ruedemann, M.D.

Miss Anita J. Stelzer
St. Louis Ophthalmic Laboratory
108 Beaumont Bldg.
3720 Washington Boulevard
St. Louis 8, Mo.
Sponsor: Adolph C. Lange, M.D.

Miss Dorothy Stobie
2804 Main St.
Buffalo 14, N. Y.
Sponsor: Joseph A. Schutz, M.D.

Mrs. Betty M. Storer
414 N. Camden Dr., Room 109
Beverly Hills, Calif.
Sponsor: James R. Cogan, M.D.

Miss Ann E. Stromberg
Orthoptic Clinic
Massachusetts Eye & Ear Infirmary
243 Charles St.
Boston 14, Mass.
Sponsor: Edwin B. Dunphy, M.D.

Miss Angela A. Swenson
Ophthalmic Motility Clinic
905 University Ave., Room 206
Madison 5, Wis.
Sponsor: G. E. Oosterhous, M.D.

Miss B. Evelyn Taylor
708 Park Ave.
New York, N. Y.
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Mrs. Louise Altick Thompson
608 Duke St.
Norfolk, Va.
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311 Doctors Bldg.
478 Peachtree St. N.E.
Atlanta, Ga.
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105 Hawes St.
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403 Fulton St.
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432½ Phoenix St.
South Haven, Mich.
Sponsor: Martin J. Urist, M.D.

Miss Mary Wackerhagen
115 E. Capital Ave.
Little Rock, Ark.
Sponsor: Dale Alford, M.D.

Miss Ruth Wahlgren
Dept. of Ophthalmology
University of Oregon Medical School
Portland, Ore.
Sponsor: Kenneth C. Swan, M.D.

Miss Frances C. Walraven
235 Strickler Bldg.
1293 Peachtree St. N.E.
Atlanta 9, Ga.
Sponsor: J. Mason Baird, M.D.

Miss Jane R. Ward
Cleveland Clinic, Dept. of Ophthalmology
2020 E. 93rd St.
Cleveland 6, Ohio
Sponsor: Roscoe J. Kennedy, M.D.

Miss Dixie Wehrheim
Medical Arts Bldg., Room 512
1211 21st Ave. South
Nashville 12, Tenn.
Sponsor: George W. Bounds, Jr., M.D.

Mr. N. LeRoy White
628 Medical Arts Bldg.
Portland, Ore.
Sponsor: E. Merle Taylor, M.D.

Mrs. Barbara Coder Williams
32 N. Washington
Ypsilanti, Mich.
Sponsor: M. A. Petrohelos, M.D.

Mrs. Marie F. Williams
Orthoptic Clinic
University of Colorado Medical Center
4200 E. Ninth Ave.
Denver 20, Colo.
Sponsor: Harry W. Shankel, M.D.

Miss Geraldine L. Wilson
11 E. 68th St.
New York 21, N. Y.
Sponsor: Herbert M. Katzin, M.D.

Miss Geraldine A. Wood
Ophthalmic Laboratory
402 Cobb Bldg.
Seattle, 1, Wash.
Sponsor: Roger Johnson, M.D.

Mr. Fletcher Woodward
1605 22nd St. N.W.
Washington 8, D. C.
Sponsor: Frank D. Costenbader, M.D.

Mrs. Marguerite Johnston Worsham
161 W. Cheves St.
Florence, S. C.
Sponsor: J. Howard Stokes, M.D.

Mrs. Kathleen Byers Ziel
Grand Rapids Orthoptic Clinic
338 Sheldon, S.E.
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